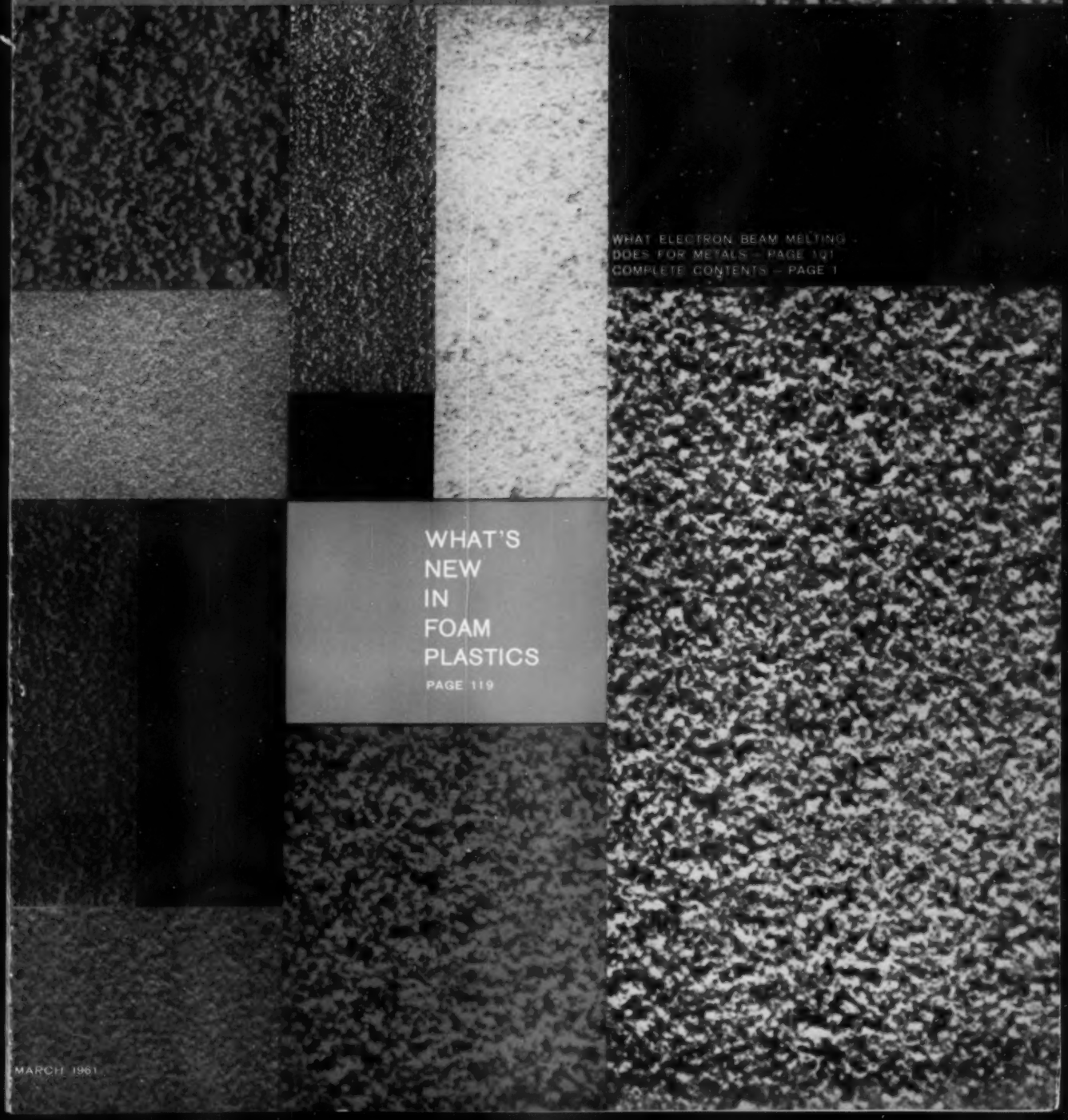
Materials in Design Engineering



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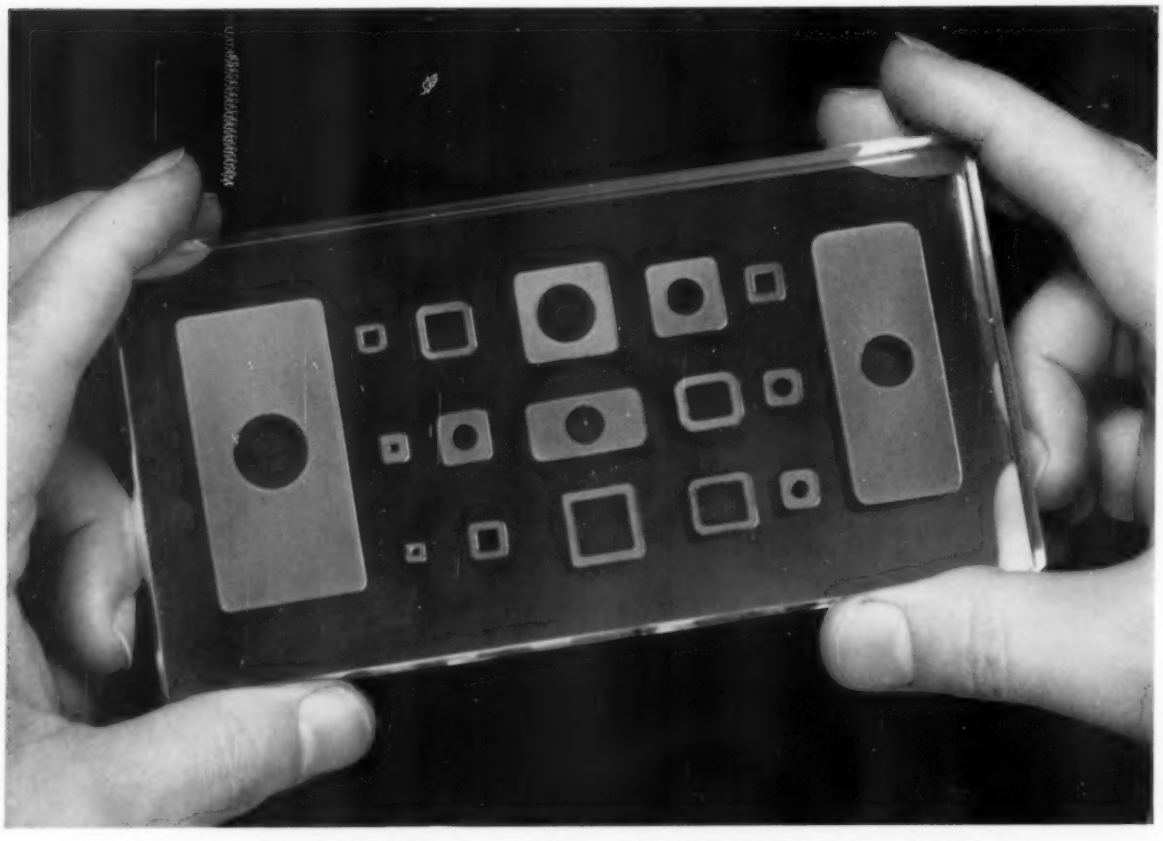
MARCH 1961

a new look at hollow conductors



Cross sections of some typical hollow copper conductors produced by Anaconda American Brass Company

Anaconda makes conductors to meet new needs in fluid cooling of windings, bus, and heat sinks

The high electrical and thermal conductivities of copper—the highest among commercial metals—are being utilized in fluid-cooled conductors to do a host of new jobs.

Fluid-cooled copper conductors are making possible more compact electrical assemblies to handle high current densities and uses are growing rapidly in large electrical equipment. Generator output, for example, can be greatly increased, without increasing frame size, by cooling the stator bars.

In such applications as heat sinks for power rectifiers and induction furnace coils—where controlled heat dissipation is essential—the use of fluid-cooled copper conductors is a natural.

Water-cooled windings produce the very high flux densities needed in the compact equipment for the ceramic magnet manufacturing process. The current range in these "solenoids" is from a few hundred to about 2000 amperes.

Of course, the most spectacular applications of fluid-cooled conductors are in nuclear physics magnets. These hollow conductors range from tube .182" square O.D. x .083 square I.D. to heavy rectangular bars with a round core for water cooling.

TECHNICAL ASSISTANCE. The cross sections of hollow conductors shown above indicate but a few of the many ways in which Anaconda American Brass is shaping copper to meet these new needs. Whatever your requirement, Anaconda specialists will gladly help you work out the size and shape best adapted to your needs. For such assistance, see your Anaconda American Brass representative, or write: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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MARCH, 1961 | VOL. 53, NO. 3

Materials in Design Engineering

FORMERLY MATERIALS & METHODS

APPLICATION OF METALS, NONMETALLICS, FORMS, FINISHES

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are you getting your METAL'S WORTH?

COST SAVING: 60%

That's how much Jamieson Laboratories estimate they save by die casting this blower housing from Zamak instead of stamping from steel. Only with a zinc die casting can they get the rugged ***thin-wall*** construction they need—***tough enough*** to take the shocks and vibration encountered in use, yet with thin-wall sections ***ductile enough*** to take extensive blanking and forming operations after casting. Neither competitive die casting material—aluminum or magnesium—nor the leading injection molded plastics, can meet these demands.

"The design is highly functional and extremely low cost compared to other methods of manufacture," says Jamieson. Can you say that of your own choice of fabrication? Are you getting your metal's worth? Remember—Zamak gives you more for less.

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Zinc and Plastic Dashboards
How Temperature Affects Modulus of 16 Alloys
Preview: Powder Metallurgy Show

This Month's Cover: *Cellular plastics design by Harry & Marion Zelenko.*

GENERAL ELECTRIC does. To produce thousands of these precise "dog pointers" on a lower cost basis they redesigned for powder metallurgy. Instead of a two-part item—which had to be machined, punch pressed, deburred, re-machined and press fit together—one punch of the compacting press at Dixon Sintaloy, Inc. does the job. Each one of the dog pointers pressed from brass powder meets tolerances of ± .001" on the diameter of the .061" hole and has the smooth, dense properties essential for plating. This is accomplished readily by GE to insure that the dog pointer matches the extra-long service life of the kilowatt-hour and other electric meters it is used in.

Think big—think powder metallurgy. For more information about the application, design techniques and properties of metal powder parts, write today to The New Jersey Zinc Company for your copy of "Designing For Pressed Brass and Nickel Silver Metal Powder Parts."

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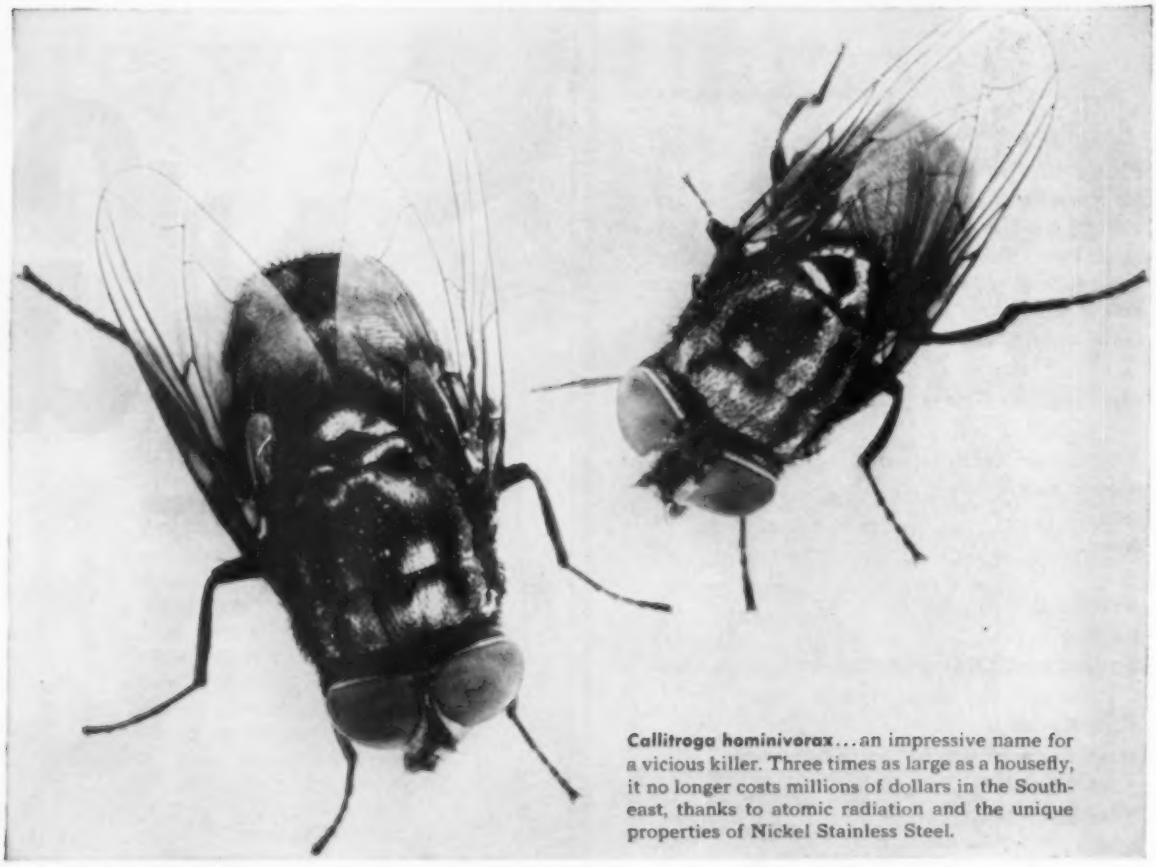


Callitroga hominivorax... an impressive name for a vicious killer. Three times as large as a housefly, it no longer costs millions of dollars in the Southeast, thanks to atomic radiation and the unique properties of Nickel Stainless Steel.

Atoms clobber a $20-million-a-year pest

How Nickel Stainless Steel helped fight costly cattle menace

A few small flies can kill a full-grown steer in ten days.

They call this killer *Callitroga hominivorax*, or screwworm fly. It used to cost Southeast cattlemen 20 million dollars a year.

Thanks to a peaceful use of atomic energy, the U.S. Department of Agriculture reports that *Callitroga hominivorax* was completely eradicated within seventeen months. This achievement may mark a new precedent in modern methods of pest elimination. Over two billion laboratory-raised male flies were sterilized by atomic radiation and then released. Because the females then laid sterile eggs, the screwworm fly population was destroyed.

Sterilization was accomplished by exposing males to gamma radiation from Cobalt 60 within a lead-shielded cask of Nickel Stainless Steel.

Nickel Stainless Steel was chosen by the designers, Knapp Mills Inc., for several reasons. It gives strength and rigidity to the cask's interior for greater handling safety. It stands up to the nitric acid solution used for radioactive decontamination — a cleaning process that plays havoc with less corrosion-resisting metals. And its sanitary, attractive appearance adds sales appeal to any product.

Are you in the atomic energy field ... or any field where you need a metal with a combination of superior properties? Consider the advantages of Nickel or one of its alloys when planning the construction of your equipment. Help with any metals problem is available from Inco. Just call or write us.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

The Irradiator, nemesis of screwworm flies, is fabricated of Nicrolum*—a Nickel Stainless Steel to which lead has been metallurgically bonded. Six of these machines brought the fly menace under control.

*T.M. of the designer-manufacturer, Knapp Mills, Inc., Long Island City, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

What's new IN MATERIALS

...AT A GLANCE

New glass-phenolic laminates compare favorably in heat resistance with glass-silicone laminates. Key to the improved laminates is a phenolic binder that does not form destructive blisters during postcuring. Typically, phenolic binders form blisters and delaminate during postcure, especially in 1/8-in. thick laminates. Erosion resistance of the new laminates is close to that of glass-silicone and far exceeds that of glass-melamine and glass-polyester laminates, according to the producer.

Source: Westinghouse Electric Corp., Micarta Div., Hampton, S. C.

A modified beryllium copper alloy is said to have better strength, ductility, corrosion resistance and machinability than presently available grades. The new alloy, expected on the market shortly, is nonmagnetic.

Source: Beryllium Corp., Box 1462, Reading, Pa.

Excellent abrasion and ozone resistance are the claims made for a modified man-made natural rubber (polybutadiene) now commercially available. The rubber withstands temperatures down to –85 F, and has moderate resistance to fuels, solvents and chemicals. Potential uses: electrical insulation, fabric coatings, and mechanical rubber goods.

Source: B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio.

Adherent gas-plated aluminum coatings on steel have been obtained successfully for the first time by decomposing tri-isobutyl aluminum in an argon atmosphere at 500 F. Tests show the coating does not peel or crack when exposed 1 hr in air at 1000 F, followed by a quick plunge in cold water. (For more information on gas plating, see M/DE, Jan '60, p 98.)

Source: J. J. Crosby, Wright Air Development Div., Wright-Patterson Air Force Base, Ohio.

Strong, low cost, woven paper fabrics may be available soon as the result of a new manufacturing process. Key to the method is a new device that permits rolls of paper to be converted into narrow yarns which are then knitted or woven into fabrics. The fabrics are strong enough to be cleaned and used repeatedly.

Source: R. H. Marks, Enterprise Equipment, Inc., 7800 Sovereign Row, Dallas, Tex.

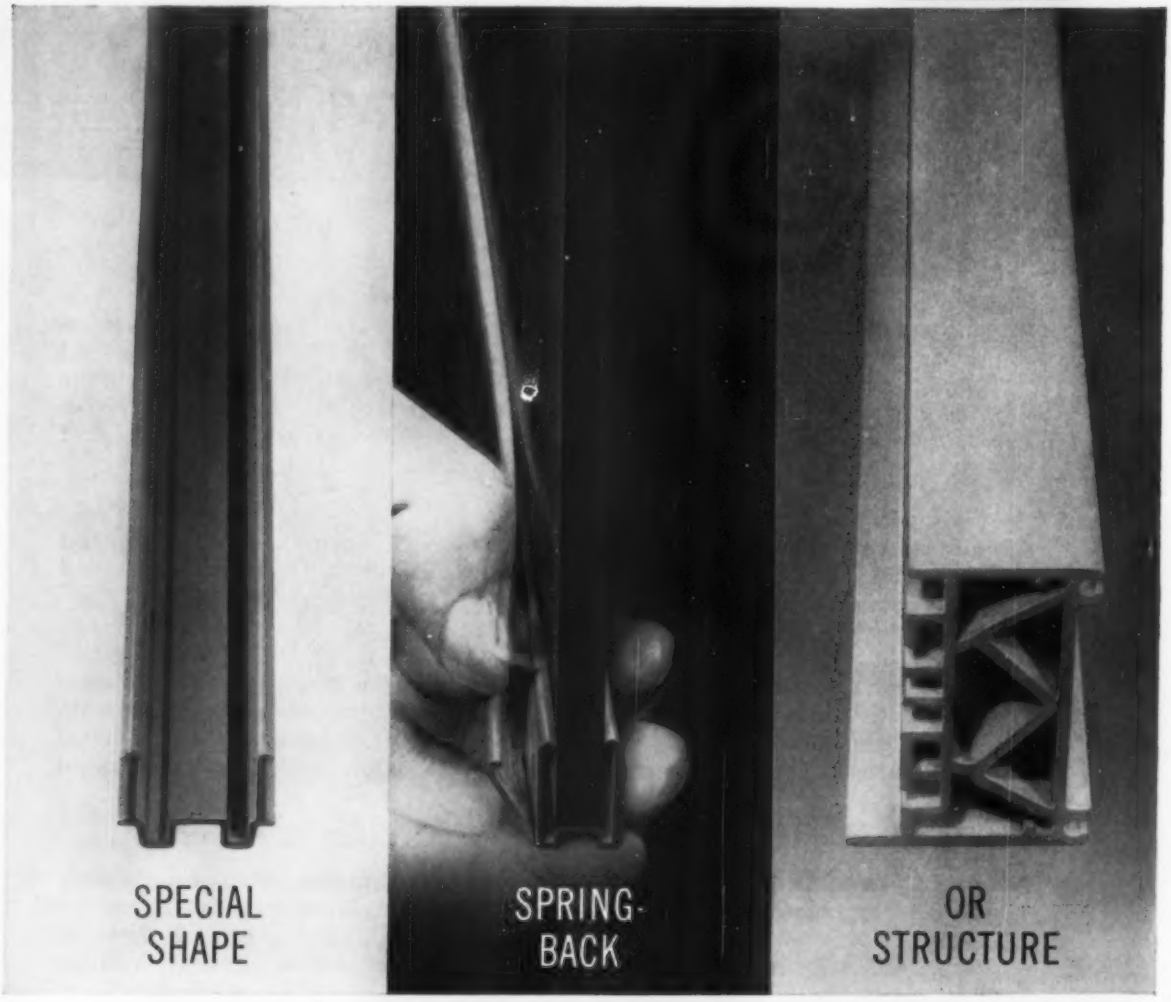
Man-made diamonds over a carat in size have been developed. However, the developer says the diamonds are not yet of sufficient mechanical strength for industrial applications because of structural imperfections. Smaller man-made diamonds have been available for the last three years (M/DE, Dec '57, p 178).

Source: General Electric Co., Research Laboratory, Schenectady, N. Y.

Two new conductive epoxy-silver adhesives are said to have good storage stability and good electrical properties at high temperatures. One adhesive is a two-part system that cures at room or higher temperatures; pot life is 90 min. The other is a one-part system that cures at 212 F or higher; pot life is one year. The adhesives

Each of these extrusions of rigid Geon by Crane Plastics, Inc., Columbus, Ohio, is in use for various architectural applications—chiefly windows. B. F. Goodrich Chemical Company supplies the rigid Geon vinyl.

B.F.Goodrich



Look how you can solve design problems with extrusions of rigid GEON vinyl

These extrusions show how the properties of rigid Geon lend themselves to solving different design problems. The special shapes show how detail can be reproduced—and it is easy to produce a long, smooth part, *straight* out of the die.

Other extrusions demonstrate how the springiness of thinner-walled extrusions gives you a spring-back characteristic for weather-stripping or rattle-proofing applications. Still others show the structural possibilities—how rigid Geon provides load-carrying strength without weight.

At the same time, each extrusion brings you all the other advantages of vinyl—unusual abrasion resistance, resistance to chemicals, self-extinguishing properties and electrical advantages. In every case there's the opportunity to mold color right in.

How can these extrusions solve your problems? We'd be glad to help you answer this question. Write Department NN-1, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio.
In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company

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Geon VINYLS

For more information, turn to Reader Service card, circle No. 349

contain a new type of conductive silver that remains stable in epoxy systems, according to the developer.
Source: Isochem Resins Co., 221 Oak St., Providence 9, R. I.

An aluminum foil honeycomb core is said to provide sandwich panels that are stronger in all dimensions than conventional honeycomb core panels. Reason: corrugations in each cross-laminated layer of aluminum foil form a 90-deg angle with those of its neighbor, and channels in alternate layers of foil run in the same direction. This design is said to provide high strength and rigidity in three planes.
Source: Aluminum Co. of America, 764 Alcoa Bldg., Pittsburgh 19.

Better looking polycarbonate plastics parts are promised with the introduction of a new, color stabilizer resin that has the same physical, electrical and chemical properties as earlier grades (M/DE, Dec '58, p 123). The producer says the new resin does not darken during molding, and has light transmittance values 5 to 10% higher than those of conventional polycarbonates. The resin is available at no extra cost in production lot quantities.
Source: General Electric Co., Chemical Materials Dept., Pittsfield, Mass.

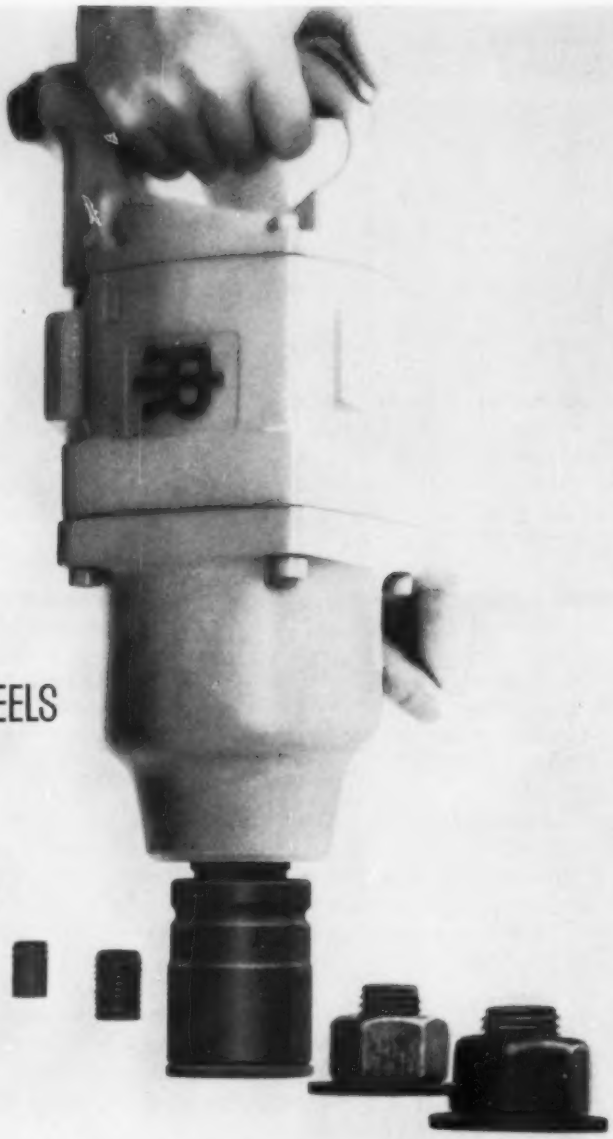
An economical process for coating the inside of metal pipe with chlorinated polyether, nylon, epoxy and other plastics has been developed. Powdered resins brought into contact with the heated pipe fuse to the inside surface in a continuous layer. Coatings are applied in a matter of 6 or 7 sec, considerably less time than that required in other pipe coating processes. (More details next month.)
Source: Engelhard Hanovia, Inc., Newark, N. J.

A low temperature, fluxless solder for aluminum is now commercially available. Previously, aluminum had to be soldered with corrosive fluxes because of the oxide film on the metal. Composition of the new solder has not been revealed, but the developer says it flows easily, has good corrosion resistance, melts at about 400 F, and wets aluminum readily.
Source: Metals for Industry Inc., 299 Pavonia Ave., Jersey City 2, N. J.

A foam plastic resistant to oil and gasoline is now available as boards 18 in. wide by 9 ft long. The new styrene-acrylonitrile foam is designed for buoyancy applications in boats and in floating structures that are exposed to a combination of stagnant water and heavy gasoline spillage. Conventional polystyrene foam is only moderately resistant to gasoline and oil.
Source: Dow Chemical Co., Midland, Mich.

A new high strength thermoplastic—an acetal copolymer—promises tough competition for presently available Delrin acetal resin. The new resin is said to have better resistance to chemicals, cold flow and high temperature creep than Delrin. Moldability is also said to be improved. Other properties, according to released data, are similar to those of Delrin. The new resin, called Celcon, is available in pilot plant quantities. Introductory price is 70¢ per lb, compared to 65¢ per lb for Delrin. (More details next month.)
Source: Celanese Polymer Co., Div. of Celanese Corp. of America, 180 Madison Ave., New York 16.

Turn to page 9 for more "What's New in Materials"



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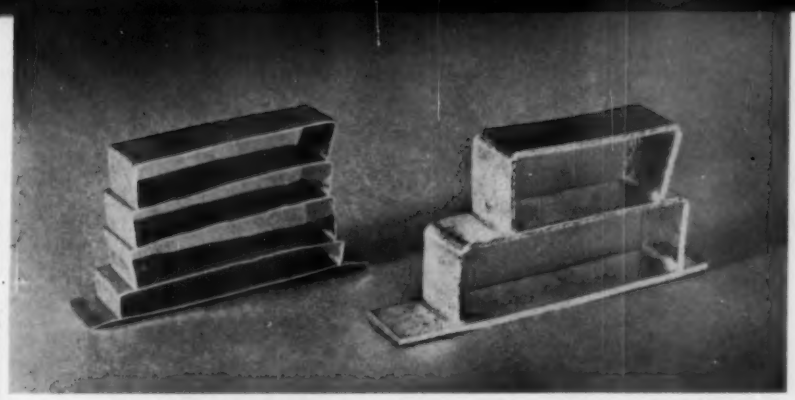


***Two diffusion bonded** assemblies show how parts can be joined when only the surface has been coated. Edge-to-surface joint assemblies are 0.005-in. thick strips (left) and 0.025-in. thick strips (right).*

New Coating for

Diffusion Bonding Copper

promises lower assembly costs. Still developmental, it may be available on mill products in future.

■ A coating has been developed by Chase Brass & Copper Co., Waterbury, Conn., that will permit diffusion bonding of copper products. The joints produced retain virtually all of the high thermal and electrical conductivity of copper, a distinct advantage for many electrical and electronic applications.

The coating itself is a lacquer which carries a dispersion of finely ground phosphorous-copper powder. Although the coating is not commercially available at this time, experimental samples can be obtained from Chase Brass. Future plans include the marketing of the coating itself, as well as precoated copper mill products.

Three ways to use coating

There are three methods for making diffusion bonded joints:

1. Coating is applied to the copper mill product or fabricated part prior to joining by diffusion bonding.

2. At least one of any two components to be joined is made of copper strip coated prior to final rolling.

3. An insert of thin-gage precoated strip, coated on both sides, is used to join any two components made of uncoated copper strip or other mill form.

Diffusion bonds cannot be made with brass containing more than 5% zinc. However, a satisfactory braze type of joint, with a separate phase at the bond line, is produced when the technique is applied to brasses with a zinc content of up to 30%.

Assembly simplified

Use of copper strip, rod, wire and tube which are coated for diffusion bonding may lead to production economies by simplifying assembly operations. The integral coating may make it more practical to automate joining operations that must now be done manually.

Use of diffusion bonding should also provide savings in some applications where costly joining materials are now used. For example, major elements of advanced electronics equipment for radar, missiles and space satellites incorporate complex copper assemblies which cannot be made with common, low cost joining techniques such as soldering. It is anticipated that diffusion bonding will be useful in those applications where a requirement exists for joints which are vacuum-tight, free of high vapor pressure constituents, and able to operate at elevated temperatures.

Other possible applications include electric motors, generators, transformers, control equipment, switchgear relays, high frequency power generators, microwave devices, semiconductors and heat exchangers.

How does it work?

Diffusion bonding itself is performed by heating the coated parts at 1700 to 1800 F in an inert atmosphere (such as hydrogen) for 5 to 15 min, during which time the lacquer carrier is volatilized. Reasonably good contact of mating surfaces is required for successful diffusion bonding. The accompanying photo shows two examples of diffusion bonded specimens.

The coating can be applied to copper strip before it is rolled to finish gage or, alternatively, applied to fabricated parts before final assembly. Several types of bonds can be achieved: complete diffusion, brazed, or a combination of the two. All three make satisfactory joints.

Coated strip can be annealed in a nonoxidizing atmosphere and fabricated by the usual techniques of blanking, deep drawing, etc. Only reasonable care is required in handling the coated metal.

Mechanical properties lowered

After exposure at the diffusion bonding temperature, the base metal is fully annealed. The process cannot, therefore, be used with nonheat treatable alloys when wrought mechanical properties are required. In some cases subsequent mechanical working, such as coining or internal expansion, may increase mechanical properties. In other cases physical properties may be the important design criteria and, since these are not critically affected by the bonding process, the annealed mechanical properties will be satisfactory.

For more information, circle No. 601

High temperature bearing *must operate at 450 F. Metal bearing (left) wore and scored the shaft in less than three months. RESULTS OF CHANGE: Fluorosint bearing (right) has operated for more than a year at 450 F with no sign of deterioration.*

Ring bearings *must permit rotation and maintain strength at 300 F. High thermal expansion of TFE caused rings to buckle. RESULTS OF CHANGE: Fluorosint rings provided lower expansivity and required strength and wear resistance. No wear detected after 10,000 rotations.*

New TFE Fluorocarbon

First announced two years ago (M/DE, May '58, p 144), it also resists wear and has good electrical and thermal properties . . . a report on latest data and uses

by W. J. Davis, *Halex Corp., subsidiary of Polymer Corp.*

■ Improve one property of an engineering material and you usually sacrifice others. Now a compounded TFE fluorocarbon material is available that provides maximum compressive strength, rigidity and wear resistance, with no sacrifice in the inherent electrical, chemical or thermal properties of TFE fluorocarbon (Du Pont's Teflon).

The new material, called Fluorosint, consists of TFE resin compounded with new proprietary inorganic materials. Many filled and reinforced TFE fluorocarbons are commercially available. Comparison with each type would be impossible here. The purpose of this article is to present all design data available on this new material, primarily in comparison with unmodified TFE and nylon. . . . You make the comparison with other TFE compounds.

Highlights in brief

The most outstanding properties of the material are 1) low deformation under load, 2) high flexural modulus of elasticity, 3) high hardness, 4) high permissible PV range, 5) low and consistent coefficient of thermal expansion, and 6) excellent retention of TFE's basic electrical and chemical properties.

Table 1 compares typical properties of the material with those of unmodified TFE fluorocarbon and nylon. A typical range of properties obtainable with commercial filled or reinforced TFE materials is also included for comparison (remember, however, that the ranges given for other commercial materials are ranges obtainable for each property, and that a combination of the best values shown is not generally obtainable in a single material).

In stock shapes, Fluorosint is available as rod, disk and tubular bar; sheet production is being considered. The material can be cold pressed and sintered to extremely close dimensional tolerances. Inherently, the material's cost is comparable to that of unmodified TFE fluorocarbon; initially, however, cost may be slightly higher.

Physical properties

The new material can outperform both nylon or TFE as an unlubricated bearing. Fig 1 shows that Fluorosint can operate at much higher PV values (load per unit area times shaft surface speed) than either of the other materials. This improved performance permits the material's use at elevated temperatures where nylon degrades and TFE deforms readily.

Fluorosint can be used in stressed applications at temperatures as high as 500 F. At 500 F, Fluorosint retains a flexural modulus of 144,000 psi, as compared with 6500 psi for unreinforced TFE (nylon's melting point is about 500 F).

Fig 2 compares hardness vs temperature for the new material with

Insulators *for the electrode of an infrared analyzer need good dielectric properties, low thermal expansion, and chemical inertness. TFE's high expansivity caused spurious signals. RESULTS OF CHANGE: New material had expansivity similar to that of aluminum housing, yet maintained other useful properties of TFE.*

Supports *for feedback assembly of a stable local oscillator (stalos) require good dielectric properties, resistance to cold flow, and low thermal expansion. Also, low dissipation factor at uhf, and retention of properties at 230 F. TFE parts were subject to cold flow. RESULTS OF CHANGE: New materials met all requirements with no distortion, permitting simple assembly and reassembly with no mismatch.*

Compound Is Strong, Rigid

that of unfilled TFE and nylon. Fig 3 compares compressive stress versus deformation with that of TFE fluorocarbon at various temperatures.

The material's relatively wide service temperature range emphasizes the importance of thermal expansion characteristics. As shown in Table 1, expansion of the new material is lower than that of either TFE or nylon, and lower than that of other known filled TFE materials, except fiber-backed laminates. Fig 4 shows effect of temperature on thermal expansion. Note that thermal expansion of Fluorosint is of the order of magnitude of aluminum's and is only twice that of steel.

The low expansion of the material also minimizes effect of thermal shock. Fig 5 compares effect of thermal shock on dimensions of Fluorosint and unfilled TFE.

Electrical, chemical properties

As shown in Table 1, Fluorosint retains the bulk of unmodified TFE fluorocarbon's excellent electrical insulating characteristics. Dielectric strength, surface and volume resistivity and dissi-

TABLE 1—COMPARISON OF PROPERTIES

Material →		Fluorosint	Unmodified TFE Fluorocarbon[a]	Nylon[b]	Commercial Compounded TFE Fluorocarbons[c]
PHYSICAL PROPERTIES	ASTM				
Specific Gravity		2.3-2.4	2.1-2.2	1.14	—
Tensile Strength, 1000 psi	D638	1-2.5	1.5-3.0	9-12	0.5-8.0
Elongation, %	D638	10-200	75-300	25-200	5-200
Flex Mod of Elast, 1000 psi					
At 75 F	D790	465	50-90	200-420	75-200
At 212 F	D790	440	28.5	70-95	50-115
At 500 F	D790	144	6.5	—	10-25
Deformation Under Load (1200 psi; 24 hr), %					
At 200 F	D621	0.2	14-18	1.0-3.0[d]	0.4-10
At 500 F	D621	1.2	22-30	—	10-20
Hardness (Shore)		D70-75	D50-60	D75-85	D60-65
PV Range (unlubricated)[e]		15,000	1000	5000	1000-10,000
Coef of Friction[f]		0.16	0.12-0.24	0.19-0.37	0.15-0.25
Lin Coef Ther Exp, 10^{-5}/°F					
70-140 F	D696	1.1	7.5	5-5.5	3-6.5
70-400 F	D696	1.4	9.5	—	4-8
ELECTRICAL PROPERTIES					
Dielectric Strength (0.08 in.), v/mil	D149	300-400	400-500	300-400	200-400
Surface Resistivity, ohms	D257	3.6×10^{12}	3.6×10^{12}	—	3.6×10^{12}
Volume Resistivity, ohm-cm	D257	1×10^{15}	1×10^{15}	4.5×10^{13}	1×10^{15}
Dielectric Constant ($60\text{-}10^9$ cps)	D150	3.3-3.45	1.95-2.10	4.1[g]	2.4-5.0
Dissipation Factor ($60\text{-}10^9$ cps)	D150	0.0005-0.001	0.0005	0.014[g]	0.0005-0.01

[a] Du Pont's Teflon.
[b] Values generally given for equilibrium moisture content in air, i.e., 2.5%.
[c] Includes general range of values for both filled and reinforced materials: bear in mind that optimum values for each property are not obtainable in one material.
[d] At 2000 psi and 122 F.
[e] Load per sq in. of bearing area times velocity in ft per min.
[f] Tested with thrust washer device against steel plate, at PV of 1000.
[g] At 60 cps.

TABLE 2—TOLERANCES FOR SINTERED FLUOROSINT PARTS (IN.)

DIAMETER, IN.	
0 to ¼	±0.001
¼ to ½	±0.002
½ to 1	±0.003
1 to 1½	±0.005
LENGTH, IN.	
Under ¼	±0.002
¼ to ½	±0.003
½ to 1	±0.005
1 to 2	±0.015

pation factor are virtually unchanged. Dielectric constant is somewhat higher.

The new TFE composition is also quite similar to unmodified TFE in that it is inert to almost all chemicals. It is affected slightly by long term exposure to hot concentrated alkali solutions. In certain applications it has outlasted type 316 stainless steel in caustic soda at 180 F. It is unaffected by organic compounds except a few fluorinated compounds such as the Freons which cause swelling.

Forming, fabricating

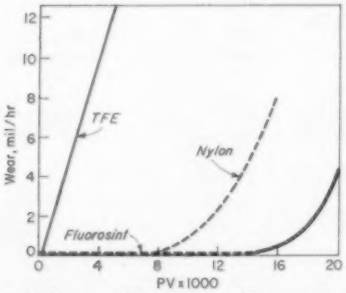
Fluorosint is molded by the same cold pressing and sintering procedure used for molding unmodified TFE fluorocarbon. However, close tolerances on moldings are relatively easy to hold. Fig 6 compares generally obtainable tolerances on molded Fluorosint with those of nylon and unmodified TFE. Table 2 shows tolerances easily obtainable in relation to size.

Size and shape — Design rules affecting size and shape of metal powder parts generally apply to molded Fluorosint parts. Whenever possible, eliminate sharp corners. Avoid abrupt changes in cross section. Avoid narrow splines as they require expensive die maintenance. Secondary machining will be required for radial projections, reentrant angles, internal grooves, undercuts, threads and lateral holes. As-molded surface finish is generally 32 μ in. or better.

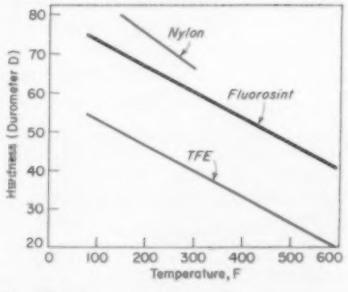
Machining—Because of its lower thermal expansion and improved dimensional stability, Fluorosint can be machined to close dimensional tolerances much more easily than unmodified TFE fluorocarbon. It can be machined at speeds and to tolerances similar to those obtainable in nylon. However, the comparatively abrasive nature of the material requires that carbide cutting tools be used.

Good machining practice applicable to all thermoplastics apply. Carbide tools should be kept sharp and provided with adequate clearance. Tools must be carefully honed. Vibration and chatter must be avoided. In general, very high speeds with relatively low feeds produce the best results.

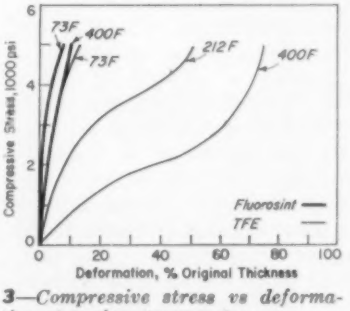
For more information, circle No. 602



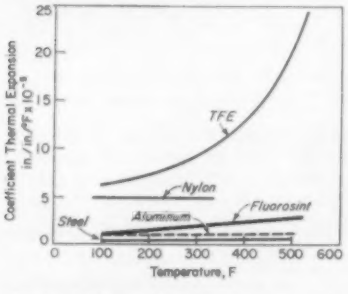
1—Wear vs PV factor. Tests were run on special thrust bearing device: Mating surface of steel was hardened to Rockwell C65; surfaces unlubricated. Surface speed was 85-400 fpm; load, 10-200 psi.



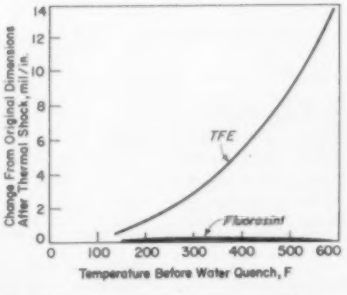
2—Hardness vs temperature.



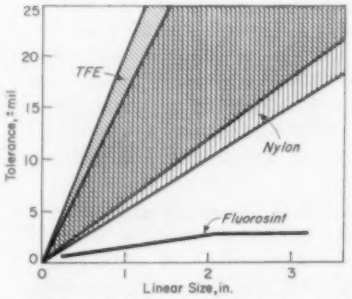
3—Compressive stress vs deformation at various temperatures.



4—Coefficient of thermal expansion vs temperature.

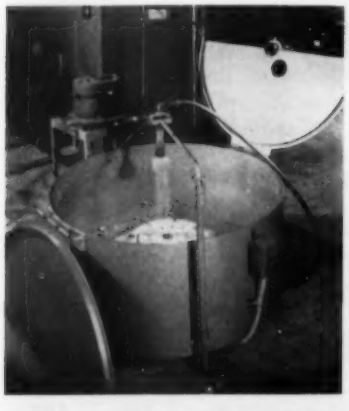


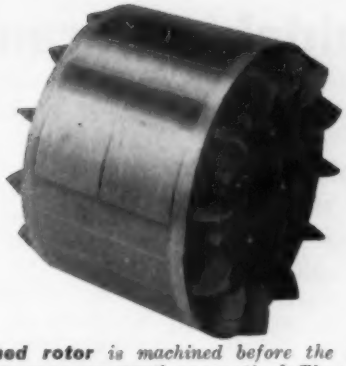
5—Effect of thermal shock on dimensions of part.



6—General dimensional tolerances of molded parts.

1 Preheating the rotor assembly *(above) and the centrifcast (below) improves bonding and eliminates bubbles.*





How it's done

Finished rotor *is machined before the imbedded magnets are permanently magnetized. The rotors are used in transportable motor-generator units.*

Aluminum Generator Rotors Are Centrifugally Cast

Lightweight generator rotors are being made by centrifugally casting aluminum around the steel laminations, magnets and binding rivets. American Marc Inc., 1601 W. Florence Ave., Inglewood, Calif. uses this method to assure complete penetration of the steel structure with a material that is light, nonmagnetic, and strong enough to provide structural permanency. Use of aluminum instead of iron saves about 80% of the rotor weight. Here is how they are cast.

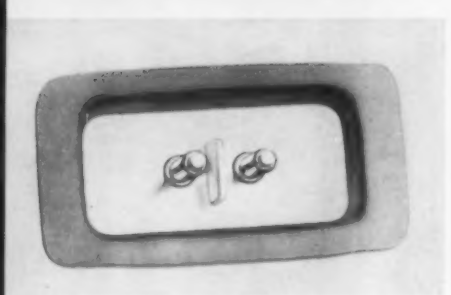
2 Cover mold *is lowered over the rotor positioned on the spin table for casting.*

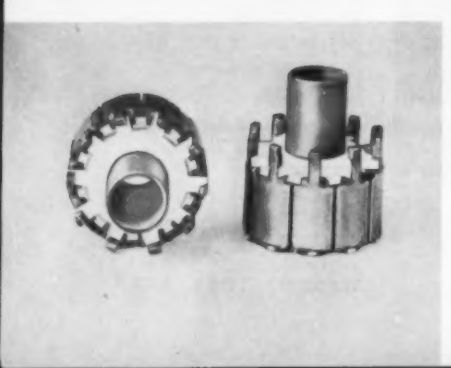
3 Aluminum is poured *into the cover mold through the funnel. The rotor spins at 800 rpm until aluminum penetrates the entire structure.*

4 Finished casting *is removed and is ready for machining.*

Moldable Ceramoplastic for 1200 F Is

It maintains high resistivity when hot, and wets metal inserts to provide hermetic seals automatically when molded





***Hermetically sealed** parts made of new ceramoplastic. Top to bottom: chip detector plug for aircraft crankcase; connector for electric hospital dish; and commutator for auto.*

■ A ceramoplastic dielectric that can operate continuously at temperatures as high as 1200 F can now be molded into precise, complex parts. Previously it had been available only in a machinable grade.

The new material, known as Supramica 620 BB, is produced by Mycalex Corp. of America, Clifton Blvd., Clifton, N. J. Like the earlier Supramicas, the new material is a mixture of synthetic mica and lead borate glass binder.

Hermetic seals and commutators appear to be two major potential applications.

Many properties improved

Properties of the new grade are compared with those of the best high-temperature moldable grade previously available, Supramica 560, in the accompanying table. The five most important improvements are these:

1. *Volume resistivity* at 932 F is the highest yet achieved in these materials: 1 x 10^8 ohm-cm.

2. *The T_e value* (the temperature at which a volume resistivity of 1 x 10^6 ohm-cm is obtained) has been boosted almost 500 °F to about 1150 F.

3. *Heat distortion temperature* based on 264 psi load has been raised almost 230 °F to about 1100 F.

4. *Dimensional stability* is maintained about 270 °F higher. The continuous operating limit for the new material is at least 1200 F—and possibly higher, according to Mycalex spokesmen.

5. *True hermetic seals*, which can be achieved in the molding process itself without extra steps, show helium leakage rates of less than 2 x 10^{-10} cu cm per sec—equivalent to less than 1 cu cm in 150 years—after severe environmental cycling.

Other important properties: its thermal expansion coefficient closely matches those of many common metals and alloys, and its inorganic nature makes it impervious to oil, water, humidity and organic solvents. Loss factor is low, dielectric strength is high, and the material will not carbonize to produce a conducting path.

The material is moldable to what the producer calls "gage-like tolerances."

How parts are made

The new 620 BB grade and the lower-temperature moldable Supramicas are made in the form of pellets. These are heated in a furnace at a temperature high enough to melt the glass binder, producing a viscous molten mass. This is forced into cooler molds under high pressure. The molding is removed when it has cooled below the melting point of the glass binder.

In the case of 620 BB, furnace

HOW NEW CERAMOPLASTIC COMPARES WITH OLDER ONE

Grade →	Supramica 560[a]	Supramica 620 BB
ELECTRICAL		
Dissip Factor (1 Mc)	0.0020	0.0023
Dielec Const (1 Mc)	6.7	8.8
Loss Factor (1 Mc)	0.014	0.020
Dielec Str (1/8 in. thk), v/mil	350	270
Arc Res, sec	250	300
Vol Res, ohm-cm		
77 F	1 x 10^{14}	1 x 10^{15}
212 F	2 x 10^{11}	1 x 10^{14}
932 F	—	1 x 10^{8}
THERMAL		
Max Operating Temp (unstressed), F	932	1200
Heat Dist Temp (264 psi), F	870	1100
Coef of Ther Exp (68-572 F), 10^{-6} per °F	6.3[b]	5.2
Ther Cond (212 F), Btu/hr/sqft/°F/ft	0.362	0.290
T_e Value, F	662	1148
MECHANICAL		
Ten Str, psi	4000	5000
Compr Str, psi	25,000	30,000
Flex Str, psi	12,000	12,000
Mod of Elast, 10^6 psi	8.0	12.0
Charpy Impact Str, ft-lb/sq in.	0.4	1.2
Rockwell M Hardness	120	110
Specific Gravity	2.7	3.8

[a] Best high-temperature moldable grade previously available.
[b] 32-572 F.

Vacuum-Tight

temperature is over 1800 F and mold temperature about 700 F.

Supramica parts are made on a custom basis by Mycalex Corp. of America and two subsidiaries These companies also produce components using the older type of glass bonded mica (Mycalex) in which natural, not synthetic, mica is the principal constituent.

New grade's nature differs

Although the chemical composition of both Supramica 620 grades —the BB moldable grade and the older machinable grade—is similar to that of the earlier Supramicas, there is an important physical difference. Unlike the earlier grades, the 620's are produced by precipitating the synthetic mica phase from solution in the glass, resulting in a fine crystalline dispersion of randomly oriented mica flakes. It is this fine, recrystallized structure that is responsible for the significant improvement in high temperature properties and vacuum tightness compared to earlier Supramicas.

Until now, the benefits of this modified structure were available only in a sintered form that had to be machined to shape. The producer will not give any details on how the moldable form was finally developed.

The new structure does not appear to be more costly to achieve than the old one, the company says. As a result, it does not expect that parts made of Supramica 620 BB will carry a price premium.

Applications

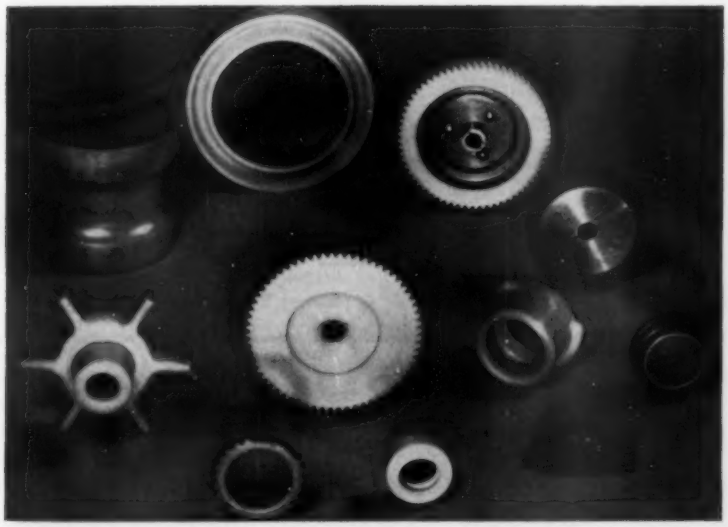
Most of the early applications of Supramica 620 BB seem to be aimed at taking advantage of its unique hermetic sealing possibilities. Its molding temperature is high enough to allow the glass binder to wet most common metals, so that seals of high integrity can be formed with metal inserts in complex configurations directly in the molding process. One restriction: molding temperatures are too high to allow sealing with semiconductor, or solid-state, materials.

A second major area of use may be commutators. Operating temperatures in many small motors—in automobiles, for example—are getting too high for organic commutators, Mycalex spokesmen say. They believe that Supramica 620 BB components in volume quantities will be able to meet the cost restrictions.

In general, the new material shows promise for applications that require excellent dielectric properties, ability to withstand high service temperatures, complex configurations, and high reliability.

New Moldable Urethane Elastomers

Precise, complex parts of abrasion resistant rubber now available in economical volume production



***Abrasion resistant** parts such as these gears and drive wheels can now be produced by economical injection molding techniques.*

■ Now you can get the abrasion resistance, toughness and strength of urethane elastomers in parts produced by high speed, multiple cavity, injection molding techniques. From the standpoint of production speed and cost, these elastomers now appear to be competitive with plastics for the first time.

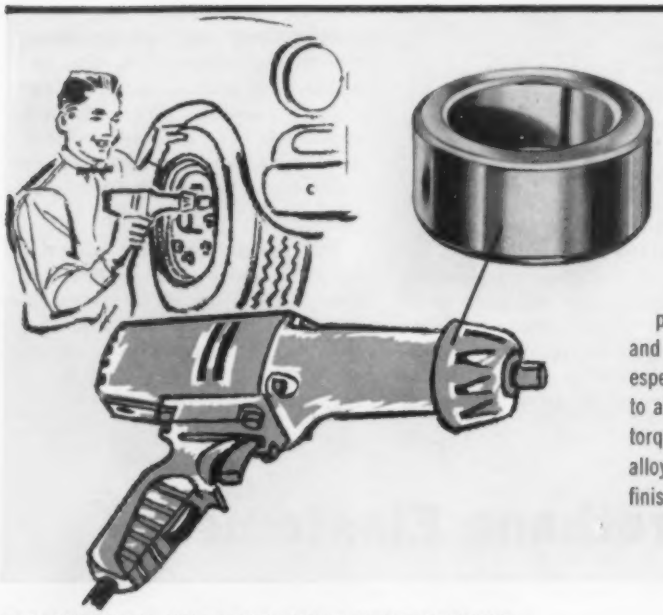
Developed by Mobay Chemical Co., Penn Lincoln Pkwy. West, Pittsburgh 5, Pa., the materials are called Texin. At present, one injection molding grade is available in development quantities. It has a hardness of Shore A92. This grade and a softer Shore A80 grade can also be extruded. Other grades in a range of hardnesses are in research.

Properties of the materials are said to be essentially the same as those of liquid cast urethane elas-

For more information, circle No. 603

600 SERIES

THE FORGEABLE BEARING ALLOYS THAT STAND UP ON THE REALLY TOUGH JOBS!



600 ALLOY NOSE BEARING WITHSTANDS THE PUNISHING SHOCK LOADS OF AN IMPACT WRENCH

This heavy-duty impact wrench takes the rigorous punishment of hard industrial use right on the nose . . . and right on the 600 Series nose bearing. This bearing was especially chosen by the manufacturer because of its ability to absorb a range of 1600 to 1800 impacts per minute at a torque of from 0 to 250 foot pounds. By specifying 600 bearing alloy, the manufacturer gets superior performance from his finished product.

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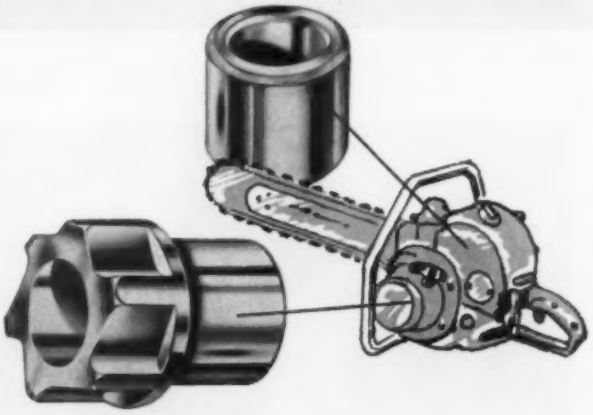
Professional woodcutters give chain saws a rough time for hours on end, all year round, and these rugged saws must be built to take punishment. With chain speeds up to 3000 feet per minute, the ratchet and drive gear bearings, for example, must have a very high strength, hardness and good resistance to wear with minimum lubrication. That's why 600 Series Alloy was specified for both parts . . . the ratchet is a forging and the bearing was produced from 600 Series rod.



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326

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tomers of comparable hardness (see accompanying table). Introductory development price is in the $1.50 per lb range (about 6.8¢ per cu in.). Although Mobay is understandably reluctant to predict future commercial price, increasing volume may reduce price considerably.

Most urethane elastomers in the past have been processed by liquid casting techniques, followed by an oven cure (see "Solid Urethane Elastomers," M/DE, Oct '59, p 92). Some types have been processable by compression molding; also millable gum types have been available, as well as one thermoplastic type. The previously available thermoplastic type (Estane, produced by B. F. Goodrich Chemical Co.) has been processed for the most part by extrusion or calendering.

TYPICAL PROPERTIES OF TEXIN VS OTHER ELASTOMERS

Material →	Texin		Natural	SBR	Neoprene
Hardness (Shore)	A80	A92	A69	A62	A72
Ten Str, psi	6500	4500	3800	3900	3800
Elong, %	550	550	440	570	470
Elong Set, %	30	45	25	12	10
Mod, psi					
100%	600	1150	450	250	470
200%	950	1550	1200	600	1300
300%	1500	2050	2250	1370	2300
Tear Str, psi	300	300	100	50	75

How they are molded

The new Texin materials are supplied as granular thermoplastic compounds. According to Mobay, injection molding cycle times are comparable to those of polyethylene and polystyrene. The materials have low mold shrinkage and their good flow characteristics permit use of multiple cavity molds.

As molded, the materials are quasi-thermosetting, i.e., they have a degree of crosslinking. Postcuring, though not necessary, increases crosslinking and improves resistance to compression set and solvents. Recommended postcure is 8-10 hr at 230 F, or 1-2 hr at 284 F. Other properties, such as strength, modulus and electrical properties are said to be only slightly affected by postcuring.

The materials are sufficiently thermoplastic as molded to permit reprocessing of scrap. Mobay reports it has reprocessed scrap material four times without obvious degradation. After postcure, the materials are thermosetting and cannot be effectively reprocessed.

How they compare

It is too early to tell just where the materials will fit. In the past, urethane elastomers have gained growing acceptance for parts requiring extreme resistance to abrasion and wear, such as wheels for materials handling trucks, airplane tail wheels, traction drive wheels, and contact wheels for abrasive grinders. These have been primarily large parts, which lend themselves to liquid casting techniques.

From the performance standpoint, urethane elastomers occupy a unique position between rubbers and plastics. They are generally stronger, harder and more rigid than most rubbers, but not as strong, hard or rigid as most thermoplastics (with the exception of such materials as polyethylenes and vinyls). But urethane elastomers provide resilience, toughness and abrasion resistance not often found in plastics.

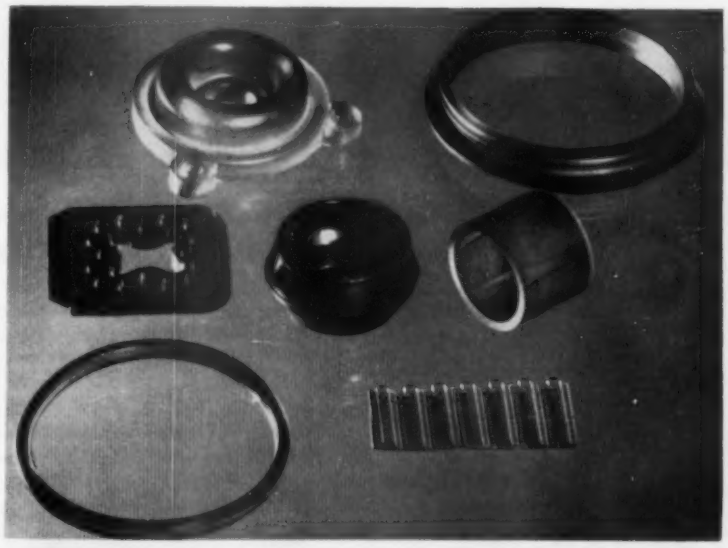
Much depends on what happens to prices. At present, Texin may compete with such materials as neoprene, nitrile and polysulfide (Thiokol) rubbers. Though the materials cost of Texin is substantially higher, the injection molding process could bring the cost of the final part down to a competitive level.

Should prices come down in the future, Mobay feels Texin may become useful for certain parts now being molded in such plastics as nylon (98¢ per lb; 4¢ per cu in.), acetal (80¢ per lb; 4.1¢ per cu in.), and possibly ABS plastics (50-60¢ per lb; 1.9-2.3¢ per cu in.).

Extrusion looks promising

Initial work at Mobay indicates the material may hold promise for extruded tubing, film and fiber. Tubing could offer advantage as an abrasion resistant sleeving for such applications as hydraulic lines, or it could be used for handling abrasive slurries. The potential as an extensible fiber has not been thoroughly evaluated as yet. Another possibility would be blow molded parts to form tough containers.

For more information, circle No. 604



Seals, gaskets and diaphragms *make use of urethane's combination of resilience and abrasion resistance.*

WHICH OF THESE STAMPINGS COSTS LESS WITH PRECISION STEEL?

All of them, as a matter of fact. The design requirements of the finished parts may—or may not—call for closer than standard tolerances. But in an intricate, high-speed operation, a variation of 0.003" could result in costly production problems—frequent delays, constant tool adjustment, a high percentage of rejects, etc.

With J&L strip steel cold rolled to precision tolerances, you can expect uniform, trouble-free stamping. The reduced production costs plus the increased product reliability will more than offset the slightly higher initial cost of precision steel.

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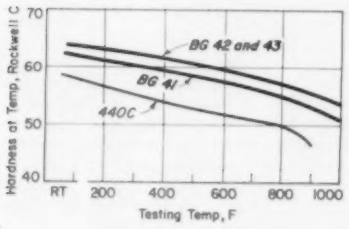
For more information, turn to Reader Service card, circle No. 449

Three Stainless Steels

retain hot hardness better than standard AISI grade 440C

■ The accompanying graph shows how three new stainless steels—Lesco BG41, BG42 and BG43—retain their hardness at elevated temperatures. The three steels were recently announced by the Latrobe Steel Co., Latrobe, Pa., and are modifications of AISI Type 440C. Compositions are compared with that of Type 440C in the accompanying table.



***Hot hardness** of new Latrobe Steel Co. alloys exceeds that of AISI Type 440C stainless steel. All specimens held at temperature for 30 min before testing.*

Molybdenum is key—In all three grades, chromium content is decreased and molybdenum substituted for improved high temperature properties. In addition, BG42 and BG43 contain increased vanadium for better wear resistance.

All three steels are available as air melted stock, and BG41 is also being produced by consumable electrode vacuum arc melting. Latrobe plans to vacuum melt BG42 and BG43 in the near future.

COMPOSITIONS COMPARED (%)

Steel ↓	C	Cr	Mo	V
440C	1.05	16.5	0.50	—
BG41	1.05	14.5	4.0	0.12
BG42	1.15	14.5	4.0	1.0
BG43	1.20	14.5	4.0	2.0

Heat treatment—The steels are austenitized between 2050 F and 2150 F and oil quenched. After a 15-min refrigeration treatment at −100 F to transform retained austenite, the three compositions are double tempered at 1000 F for 2 hr. Hardness after this treatment is 62-64 Rockwell C. The steels may be tempered at 300 to 400 F before the refrigeration treatment to minimize the danger of cracking.

For more information, circle No. 605

DAP Insulating Varnishes

are hard, resist chemicals, and withstand heat generated during soldering

■ Diallyl phthalate (DAP), already widely known as a molded insulation for electronic parts, is now available in liquid form for coating, sealing, dip encapsulation and laminating applications.

The new series of DAP varnishes, announced by Food Machinery and Chemical Corp., Chemical & Plastics Div., 161 East 42 St., New York 17, appears promising for many electronic components. In addition to resistors (see photo), the varnishes can be applied to capacitors, transformers, form-wound coils, motor windings, transistors, diodes and similar parts.

The coatings are said to offer excellent resistance to moisture, chemicals, corrosive gases, fungus, weathering, and aging over a wide temperature range.

Varnishes dipped, baked

Components are usually coated by dipping in a resin solvent solution. This is followed by a drying

(continued on p 165)

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frenchtown engineered ceramics NEWS MEMO

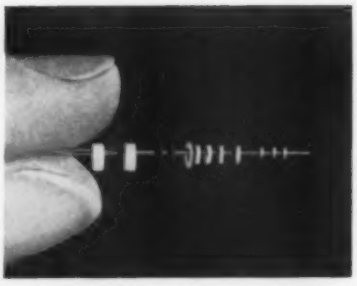
FRENCHTOWN PORCELAIN COMPANY • FRENCHTOWN, NEW JERSEY

Extremes in size shown by Frenchtown Products

The widest range of diameters in the alumina ceramic industry is demonstrated by two ceramic products currently being made at Frenchtown. Take, for example, the huge cylinder used in hydrogen fusion experiments within the C-Stellerator at Project Matterhorn, Princeton, New Jersey. Measuring 21" O.D. by 16 1/2" I.D. by 66" long, fired, this tube is produced by casting in plaster molds. A cycle of over 10 weeks is required from the preparation of mold until the ware is removed from the

kiln. Weighing over 1500 pounds, these rough castings are believed to be the largest ever produced in aluminum oxide ceramics. Subsequent diamond grinding to precise final dimensions consumes another 8 weeks.

Contrast the above with miniature semi-conductor packages, measuring .050" O.D. by .030" I.D. by .010" thick, numbering 600,000 pieces per pound. Both are made from the same

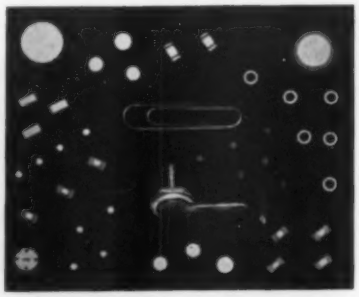


alumina ceramic material, Frenchtown's well-known #4462 Almanox.®

If you would like to investigate how Frenchtown engineered ceramics can make your product better, write stating your problem. A blueprint or sketch with specifications will bring complete information.

Beryllium Oxide Ceramics now offered by Frenchtown

Combining excellent electrical properties with high thermal conductivity, Frenchtown beryllium oxide ceramics are available in molded and extruded shapes. An extensive series of compounds with beryllia contents up to 95% affords the user a wide choice of properties, including great mechanical strength.



Frenchtown's Molcote® metallized coating may be applied to selected areas for subsequent assembly with metal parts through brazing or high-temperature soldering. Nickel, copper, gold and other plated metals are applied over the Molcote® as specified.

Demand for beryllium oxide ceramics as semi-conductor packages indicates a widespread acceptance of this material for use where heat-sink function is coupled to that of electrical insulator. Nuclear instruments and control apparatus also make extensive use of beryllium oxide's unique properties. A Frenchtown Sales Engineer would be happy to discuss specific problems with you involving the use of these versatile ceramics. No obligation, of course.

Semi-conductor Package Ceramics by Frenchtown

Headers, pads, cases, mounts, and other semi-conductor package items are being supplied by Frenchtown. Available in aluminum oxide and beryllium oxide ceramic materials, these specialties are offered either plain or metallized. Frenchtown's Molcote® metallized coating can be applied to specified areas for ceramic-metal assembly by brazing or high-temperature solder. Complete packages, including lids, bottoms, leads, and other metal parts are produced to order.

Of special interest are diode mounts with beryllium oxide pads, providing excellent heat-sink characteristics, combined with electrical insulating properties. Literature is available. Ask for Bulletin 1060.

For more information, turn to Reader Service card, circle No. 388

Two Plastics Meetings Well Attended

Two recent meetings in the plastics industry were notable for their exceptionally high attendance.

During the last week in January about 2500 members of the Society of Plastics Engineers gathered in Washington for their 17th annual technical conference. And two weeks later, approximately 1250 members of the Society of the Plastics Industry met in Chicago for the 16th annual conference of the Reinforced Plastics Div.

Many developments of interest to the materials field were described in both meetings.

For example, SPE audiences were told about: 1) a strong, clear film made from polyesters, 2) reinforced plastics for jet engines and 3) improved coatings made from furfuryl alcohol resins.

These and other developments will be reviewed in detail in the April issue of M/DE.

A total of 16 awards for outstanding performance was presented by the Reinforced Plastics Div. of SPI to authors, designers and individuals making exceptional industrial contributions.

***This closed-die forging press** now in operation at Cameron Iron Works, Inc., Houston, Tex., is the world's largest multiple ram press. Pressures up to 20,000 tons are used to forge unprecedentedly large jet engine, missile and reactor parts from high density alloy steels, tungsten, refractory metals and pure molybdenum. The 50-ft high press can produce extrusions up to 30 ft long and 56 in. in dia. Large intricate shapes can also be forged by the split-die technique.*

New Machining Data Center Privately Run

A new data center has been organized by Metcut Research Associates, Cincinnati, to aid in solving aerospace machining and materials problems. This is the first privately organized data center comparable to those established in other materials fields by the Dept. of Defense and some universities.

To be a national service

The Metcut Center will: 1) collect, analyze, correlate and disseminate all available machining and materials data on a nationwide basis; 2) provide pertinent data, recommendations or other assistance for the solution of specific machining problems and; 3) use the facilities of the parent company for the experimental development and application of collected data to specific problems.

Providing information on the working and use of refractory and other exotic metals in aerospace applications is expected to be one of the Center's chief contributions to national defense.

All types of materials included

The new Center's program is intended to provide data for machining operations on all types

of materials. Initially, data will be catalogued for metals and alloys, ceramics, cermets and plastics. Other materials will be included as the need arises.

Successful execution of the ambitious plan will provide a central information source and advisory group in fields where an immense amount of data exists but has never been readily accessible to its potential users.

Special Courses Cover Engineering Materials

Materials engineering courses open to engineers in industry are being offered in the summer and regular sessions of several leading universities. Here is a brief summary of some of them:

University of Wichita—*Production Institute (Mar 27, 28)* is jointly sponsored by the University of Wichita and the American Society of Tool and Manufacturing Engineers. Prominent speakers will discuss such topics as brazing honeycomb sections, aluminum castings, missile metals and flow turning in this seminar.

Pennsylvania State University—*Solid State Mechanics (June 11-23)* is planned for materials, research and design engineers, and other scientists engaged in various aspects of materials science. The topics discussed will include mechanics of creep, and the static stress, fatigue, shock and impact, damping and high temperature properties of materials. *Carbon Conference (June 19-23):* will cover various aspects of carbon technology in 85 papers. Topics include: surface physics and kinetics, dislocations and high temperature properties, radiation effects and structure. *Solid State Mechanics (June 11-23):* will deal mainly with the design significance of the mechanical and stress-strain properties of materials.

University of Michigan—*Engineering Summer Conference* will include the following materials courses: Semiconductor Theory and Technology (June 19-30); Machinability of Metals (June 19-24); Applications of Stress Analysis to Design and Metallurgy (July 24-28); and Mathematical Modeling for Metal Casting Processes (Aug 14-23).

Design, Plastics Shows Coming in May, June

The Machine Design Div. of the American Society of Mechanical Engineers and the Society of the Plastics Industry will hold their annual national conferences in May and June respectively.

The Design Engineering Conference and Show will be held in Cobo Hall, Detroit, May 22-25. Theme of the conference will be "How to Design for Today's Competitive Market." Over 2000 engineers are expected to attend the meeting that will feature papers by authorities in the fields of mechanical and electrical design, materials and processes.

The show, sponsored by Clapp & Poliak, Inc. and held concurrently with the conference, will consist of exhibits by more than 400 leading manufacturers.

The 9th National Plastics Exhibition and Conference to be held June 5-9 in New York City is expected to be the largest show and meeting ever held in the plastics field. The Society of the Plastics Industry, Inc., sponsor of the convention, expects an attendance of over 30,000 scientists and industrialists.

The exhibition will virtually fill the New York Coliseum and will feature displays of new materials, products, techniques and machinery. The conference will be held concurrently.

News of Societies

American Institute of Mining, Metallurgical and Petroleum Engineers has awarded the Robert Lansing Hardy Award to Dr. Jerome B. Cohen, Asst. Prof., Northwestern University, for outstanding promise in metallurgy.

American Powder Metallurgy Institute has established a section in New York for which the following officers have been elected: chairman—J. K. Shaw, S-K-C Research Assoc.; vice-chairman—J. Haertlein, Metals Disintegrating Co.; secretary—E. E. Carlson, A. Johnson & Co.; treasurer—F. W. Norton, New Jersey Zinc Co.

American Society for Testing Materials awarded Dr. Lyman E. Fourt of Harris Research Laboratories the Harold DeWitt Smith Memorial Medal for outstanding achievement in the science of textile fiber utilization.

American Society of Tool and Manufacturing Engineers, has become affiliated with the American Association for the Advancement of Science. Dr. H. Osborn, Ohio Crankshaft Co., has been named the society's representative.

Institute of Aerospace Sciences has granted the Lawrence Sperry Award to R. B. Howell, Missiles and Space Div., Lockheed Aircraft Corp., for outstanding contributions to aerospace science.

Metal Powder Industries Federation has announced that it will sponsor an award for an outstanding contribution to advancement of the industry. Presentation of the award will be made at the annual meeting of the Federation in April.

Pressed Metal Institute has elected Jefferson D. Keith as managing director.

Society of Plastics Engineers, Inc. has awarded the President's Cup to G. Palmer Humphrey of R. C. Molding Co. The award is presented to the member who has made the greatest administrative contribution to the Society during the year.

Steel Founders' Society of America has chosen its president, Wilson H. Moriarty to deliver the Newcomen address at its centennial year meeting.

HALF the world is half asleep! Men who could be making *twice* their present salaries are coasting along, hoping for promotions but doing nothing to bring themselves forcefully to the attention of management.

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Coming Meetings

STEEL FOUNDERS' SOCIETY OF AMERICA, 59th Annual meet. Chicago. Mar 11-14.

AVIATION CONFERENCE, American Society of Mechanical Engineers. Los Angeles. Mar 12-16.

TEXTILE ENGINEERING CONFERENCE, American Society of Mechanical Engineers. Clemson, S.C. Mar 16-17.

AMERICAN SOCIETY FOR METALS, 12th Western Metal Congress & Exposition. Los Angeles. Mar 20-24.

AMERICAN CHEMICAL SOCIETY, 139th national meeting. St. Louis. Mar 21-30.

PRESSED METAL INSTITUTE, spring technical meeting. Cleveland. Mar 22-24.

TEMPERATURE — ITS MEASUREMENT AND CONTROL IN SCIENCE AND INDUSTRY, Instrument Society of America. Columbus. Mar 27-31.

FILAMENT WINDING CONFERENCE, Society of Aerospace Material & Process Engineers. Pasadena. Mar 28-30.

MATERIALS FOR ELECTRON TUBES AND SEMICONDUCTOR DEVICES, American Society for Testing Materials. Philadelphia. Apr 5-7.

OIL & GAS POWER CONFERECE & EXHIBIT, American Society of Mechanical Engineers. New Orleans. Apr 9-13.

AGGLOMERATION SYMPOSIUM, American Institute of Mining, Metallurgical and Petroleum Engineers. Philadelphia. Apr 12-14.

AMERICAN WELDING SOCIETY, 42nd annual convention and exposition. New York City. Apr 17-21.

METALS ENGINEERING CONFERENCE, American Society of Mechanical Engineers. Pittsburgh. Apr 23-26.

POWDER METALLURGY SHOW, Metal Powder Industries Federation. Cleveland. Apr 24-26.

HIGH TEMPERATURE MATERIALS CONFERENCE, Cleveland Section, Metallurgical Society of American Institute of Mining, Metallurgical & Petroleum Engineers. Cleveland. Apr 26-27.

1961 CASTINGS CONGRESS AND EXPOSITION, American Foundrymen's Society. San Francisco. May 8-12.

DESIGN ENGINEERING CONFERENCE, Machine Design Div., American Society of Mechanical Engineers. Detroit. May 22-25.

DESIGN ENGINEERING SHOW, Machine Design Div., American Society of Mechanical Engineers. Cobo Hall, Detroit. May 22-25.

9TH NATIONAL PLASTICS EXPOSITION AND CONFERENCE, Society of Plastics Industry. New York City. June 5-9.

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Old foams in new cocoons

To the Editor:

On page 29 of the Dec '60 issue of M/DE there appears an abstract article relative to foamed polyurethane structures as protective materials for use in space vehicles. Particularly, we would like to direct your attention to the statement which infers that frozen foaming mixtures are a new development. This method of suspending foaming of reactive polyurethane mixtures, until such time that a foam is desired, has been of considerable interest in our laboratory since 1948.

H. A. PACE
Organic Research-Staff
Research Div.
Goodyear Tire & Rubber Co.
Akron 16, Ohio

Mr. Pace's exception is well taken. However, we did not say that the frozen foaming mixtures themselves were new, but rather that their use for foamed plastics cocoons was the new development.

Government support of materials research

To the Editor:

In your recent editorial, "Government Puts Future of Materials in Universities' Hands" (M/DE, Dec '60, p 192), you conclude by saying, "Thus, our course on basic materials research on a national level has been set. Success or failure is now largely in the laps of our universities. We are hopeful that they will succeed."

In the first place, I want to go on record as strongly favoring the government's start in supporting interdisciplinary curricula labeled "Materials Science" or whatever. This is a much better place to put money than generating scrap on CPFF contracts while needed materials engineering design data are painfully accumulated and lost as soon as a contract is terminated. The government contracts are also a much needed unrestricted subsidy for the interdisciplinary faculties teaching the fundamentals of materials science.

I cannot agree on several accounts that the future of materials is or should be in university hands under government contract, no matter how dedicated or learned those hands may be. What is wrong with our free enterprise system if the principal beneficiaries of the system, the entrepreneurs, lay back and wait for the government to furnish the basic information for the design of products whose manufacture and sale is the chief social justification for the existence of industry? Can it be that we are truly in a stage of our economic development wherein a security-seeking managerial class is willing to

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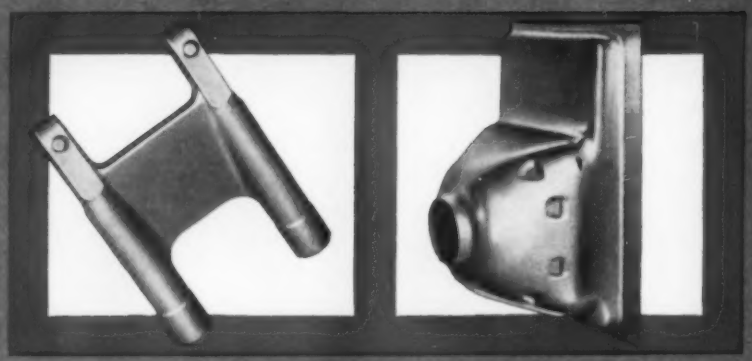
FORGINGS

TRANSUE & WILLIAMS

STAMPINGS



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let the government shoulder the costs and risks of extending the boundaries of our knowledge of the physical world while the corporations follow merely gleaning in the field? If so, we are down the road to socialism.

I cannot believe that American industry has the slightest intention of abdicating its duty and right to search out natural phenomena out of which the natural inventiveness of the human mind can devise products to serve fellow humans. I can believe in social (government) support of higher education and the research which is part of that education—therein lies the constitutional duty to "promote the general welfare." But I will never concede that the American self-reliant and pioneering spirit is moribund to the extent that fundamental materials research is largely a university function for industrial organizations to exploit if they have the wit and capital to do so.

DR. ROBERT S. SHANE
Consulting Engineer
Advance Design Engineering
Engineering Services
General Electric Co.
Utica, N. Y.

Help needed on . . . solvent resistance

To the Editor:

Your special report ("What Users Think of Polypropylene," M/DE, Dec '60, p 117) was of great interest. However, you presented no data on solvent resistance. What is the solvent resistance? What degrees of swelling occur in various solvents? Are there any emulsions of polypropylene available?

G. AHRENS
Research Dept.
International Latex Corp.
New York, N. Y.

It is difficult to state quantitatively the solvent resistance of polypropylene because resistance depends on 1) type of solvent used; 2) concentration of solvent; 3) temperature and duration of exposure; and 4) the type of exposure anticipated, e.g., one-sided, complete immersion, etc. As a general statement, polypropylene is said to have excellent resistance to most solvents at temperatures below 175 F. For more specific information polypropylene producers should be contacted. As to emulsions, we have not heard of any.

. . . basic research on fiberglass

To the Editor:

I am attempting to obtain literature, or references to literature, on the basic research that has led to the many commercial applications of fiberglass today. Any information you can furnish will be greatly appreciated.

JAMES C. PAYNE
Major, Air Force Reserve
Bedford, Mass.

Information has been sent.

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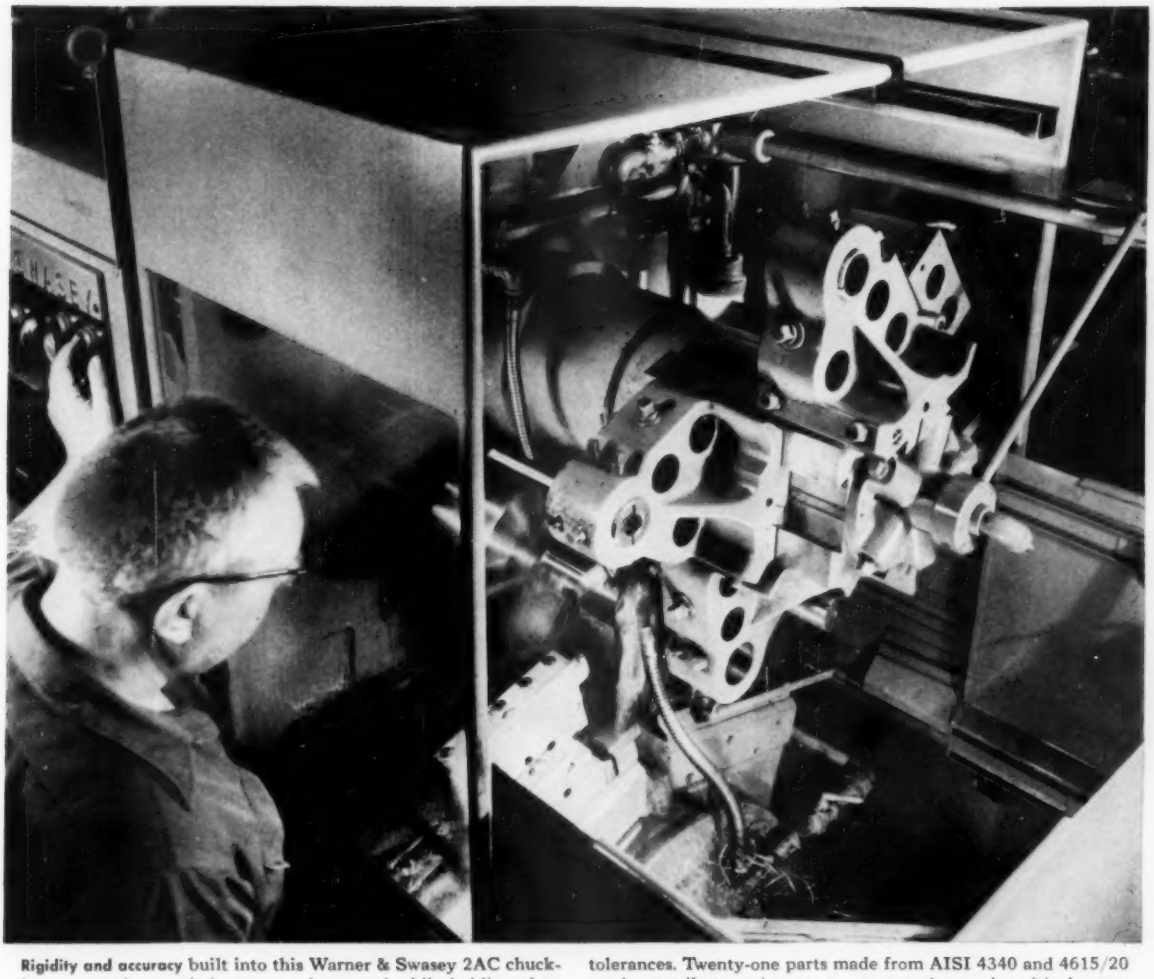

Rigidity and accuracy built into this Warner & Swasey 2AC chucking automatic permit heavy metal removal while holding close tolerances. Twenty-one parts made from AISI 4340 and 4615/20 steels contribute resistance to stress and wear in critical areas.

Warner & Swasey uses two nickel alloy steels to give the 2AC built-in rigidity and accuracy

Variety of parts made from 4340 and 4615/20 for long-term resistance to impact and wear.

Here's where the Warner & Swasey Company relies on AISI 4340 and 4615/20 to help maintain the rigidity and accuracy for which this 2AC single spindle chucking automatic is fast becoming famous.

Four clutch plates, for example, are made of 4340. Through-hardened for these parts, this 1.85% nickel steel provides dimensional stability in heat-treatment and in high-temperature operation . . . in addition to vital resistance to shock-loading and torsion.

Shafts, guide blocks, studs, plungers, and clamp strips are just a few of the parts in the versatile 2AC made from another nickel alloy steel: AISI 4615/20. These components are carburized and hardened for wear-resistance to maintain accuracy throughout a long service life. And the *uniform* hard case is backed up by a strong, tough core that stands up to severe impact and torsional stresses.

This report is typical of the many coming in from manufacturers who have employed these two General Purpose Steels for a variety of machinery components.

Both these steels are readily available, right off the shelf at your local Steel Service Center. Together they give you a double-barreled way to cut costs and still satisfy almost all your alloy steel needs. Other nickel alloy steels, possessing special properties for specialized applications, are also widely available.

Consider nickel alloy steels for gears, shafts, bearings, and other machine parts you design, order, or use. And for engineering information to help you select the right material for the job you have in mind, just write to Inco.

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NS SPECIAL WIRE WITHSTANDS 1000°F

Landing hot jets like the McDonnell Phantom II at high speeds, means brakes and brake components must be able to withstand extreme temperatures without failure.

A leading manufacturer of brakes for jet aircraft came to National-Standard for help in finding a spring wire that would have high stress-temperature stability up to 1000°F. National-Standard engineers recommended an austenitic superalloy material, NS-A286, recently developed for spring wire applications by National-Standard. Tests showed that NS-A286 met requirements better than any other available alloy, yet cost only half as much as the next best alloy.

SUPERALLOY PASSES TEST—When brakes on the Phantom II are released, the NS-A286 return springs under the brake discs must separate the stationary stator discs from the moving rotor discs. The brake discs build up heat to 1400°F, which is quickly absorbed by the return springs, raising spring temperatures to as much as 1000°F. NS-A286 is a precipitation hardening alloy exhibiting as little as half the relaxation loss at 1000°F as comparable alloys show at 850°F. NS-A286 springs must retain their strength at this heat to separate the brake discs and guard against brake drag during landings.

To test NS-A286, engineers simulated stress-temperature characteristics of three landing conditions.

TO BRAKE JETS

Heat builds up in the brakes in 30 seconds and remains for as long as 20 minutes. The springs must work in the heat against a high back pressure maintained in the aircraft hydraulic system. Springs must be operational for at least 45 normal landings, 5 high-speed, gross weight landings, and one aborted take-off stop, corresponding to stopping the plane just before it becomes airborne. Under all test conditions, NS-A286 met every rigid requirement.

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NS-A286 SUPERALLOY WIRE, produced by National-Standard, meets critical stress-temperature demands for coaxial return springs in brakes of F4H-1 Phantom II.

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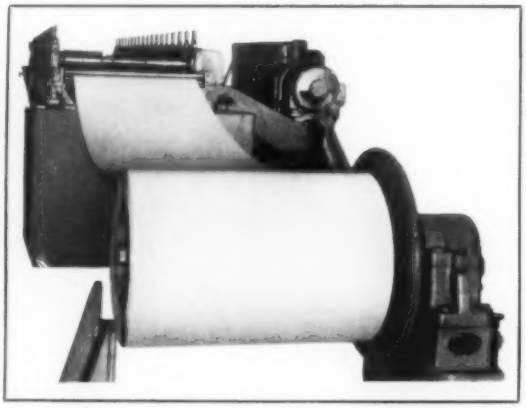

A coil of Bonderized, pre-finished galvanized steel feeds into roll former at a Butler plant.

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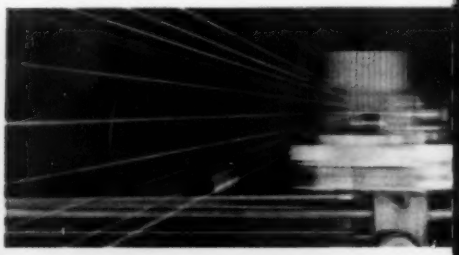

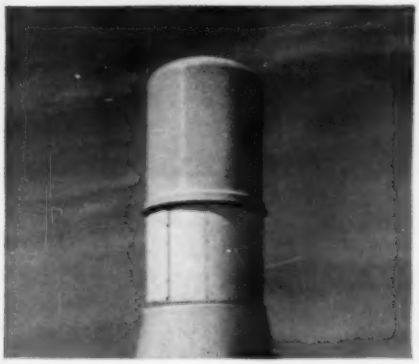

soon dot the landscape from coast to coast. CIBA Araldite® Epoxy Resins, used as structural laminates for woven fiberglass constructions, provided the solution. At the same time these versatile resins developed by CIBA were making possible the mass production of antenna structural parts and sturdy, compact embedment of many delicate electronic elements used in Vortac units.

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Welded Steel Tubing. Babcock & Wilcox Co., Tubular Products Div., 8 pp, illus., No. T-459. Characteristics, advantages, and ordering information for electric resistance welded steel mechanical tubing, hydraulic line tubing, and cylinder tubing. **4**

Steel Castings. Blaw-Knox Co., 44 pp, illus. Description of services and facilities available for the production of large steel castings. Discusses design, molding, steel-making, pouring, cleaning and finishing, heat treating, machining, and testing and inspection. Includes specifications and some typical applications of large castings. **5**

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Polyester Premix Compounds. Celanese Corp. of America, Celanese Polymer Co., Div., 6 pp, No. MIE. Information on resins, reinforcements, fillers, mixing equipment, compounding procedures, molding equipment, molding techniques and operations, design, and typical premix formulations. **7**

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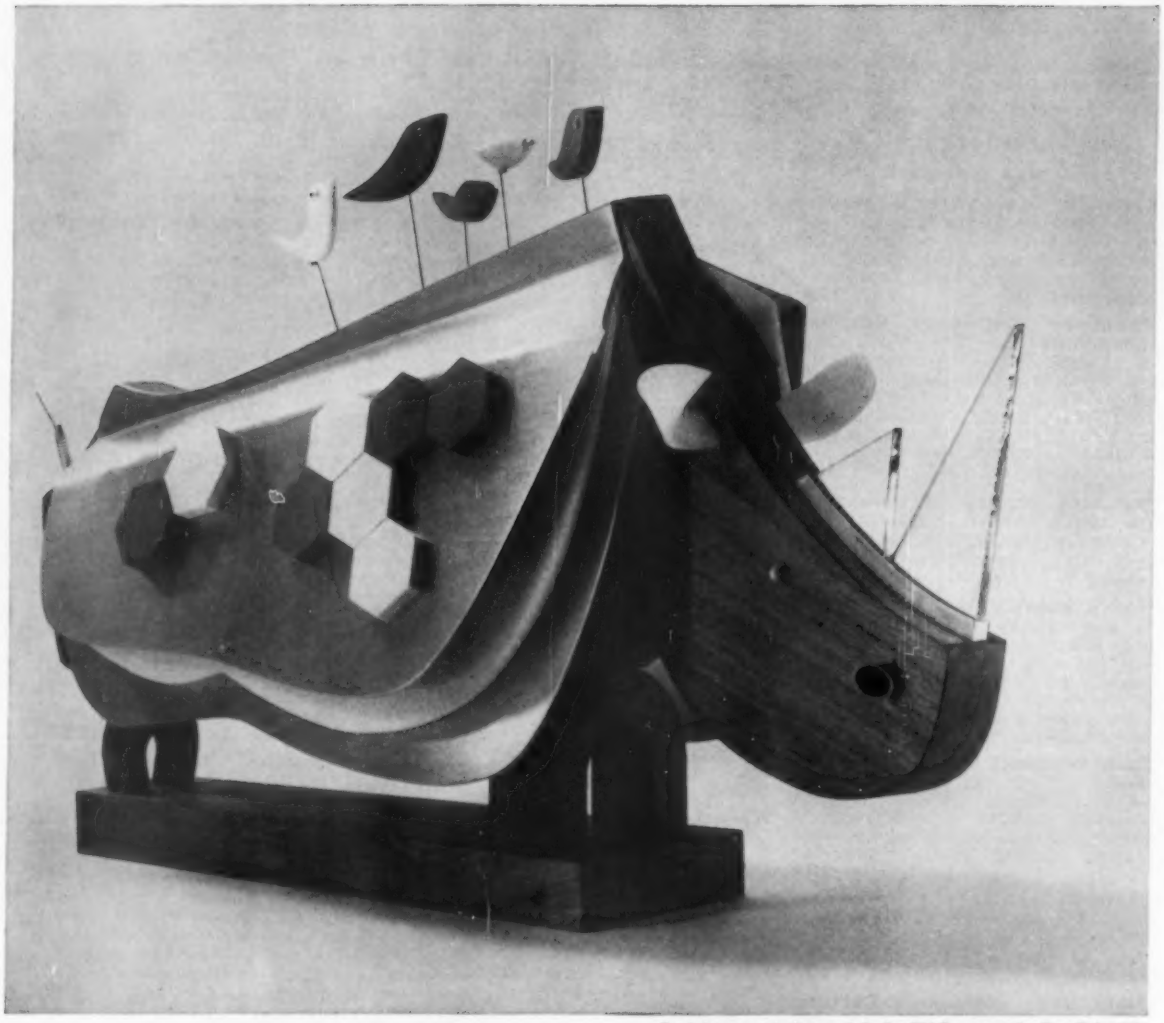

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Whatever materials you're bonding (to the same or to another material), a SCOTCH-WELD Brand Structural Adhesive bond will give you a bonus of structural strength at the joint, with the flexibility to resist vibrational fatigue. SCOTCH-WELD adhesive bonds distribute stress loads uniformly, and protect the strength and integrity of the materials by eliminating fastening holes, maintaining the finish, and sealing joints against corrosion.

Fatigue tests show that metal-to-metal joints in Convair's 880 jet transports and Air Force F-102A jet interceptors, bonded with SCOTCH-WELD adhesives, will outlast the metal structure they bond together! In industry, too, SCOTCH-WELD adhesives are finding use in joining hermetically sealed metal shipping containers, multiple piece castings and thinner gauge metals, where tear strength would limit the effectiveness of other joining methods.

Look first to 3M! A pioneer in adhesive research, 3M has developed the widest line of adhesives in the industry. These Technical Service facilities are at your disposal. For an accurate appraisal of how an adhesive can add strength, light weight, production economy, and greater design freedom to your process or product, call your nearest 3M Field Engineer or write to: AC&S Division, 3M Company, Department SBHH-31, St. Paul 6, Minnesota.

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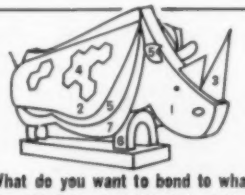

What do you want to bond to what?

The 3M Rhino is fabricated of these materials and bonded with SCOTCH-WELD Brand Structural Adhesives:

1. Wood 2. Aluminum 3. Glass 4. Ceramic
5. Plastic 6. Permanent Magnet 7. Brass

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TECHNICAL LITERATURE

(cont'd from p 47)

Books

Cobalt: Chemistry, Metallurgy and Uses. *Edited by Roland S. Young. Reinhold Publishing Corp., New York. 1960. Cloth, 6 by 9 in., 424 pp. Price $15*

This comprehensive survey (written by several experts) of the production, consumption, chemistry, metallurgy, and applications of cobalt, brings up to date a previous book written entirely by the editor.

The new book is designed to interest both chemists and metallurgists.

In addition to a summary of new developments, the book covers: occurrence of cobalt; extractive metallurgy; chemical and physical properties; simple compounds; coordination compounds; phase diagrams; magnetic, electrical and electronic applications; high temperature, high strength service; tool steels; cemented carbides; electroplating; use in the glass and ceramic industries; catalytic behavior; biology and biochemistry; radioactivity; and analysis.

Steel Castings Handbook: Third Edition. *Edited by Charles W. Briggs. Cleveland. 1960. 6 by 9¼ in., 670 pp. Price $5.50*

This handbook, a completely revised and rewritten version of the 1950 edition, incorporates much new information, and is now said to be the "most comprehensive source of data on the proper design, selection and heat treatment of steel castings in the world today."

Included in the new book: advantages, applications and purchasing of steel castings; patterns; tolerances; normal variations; carbon and low alloy steels; resistance to wear, corrosion, and high and low temperatures; welding; heat treatment; casting practice; casting design; machinability; a glossary of foundry terms; and engineering tables dealing with compositions and specifications for wrought and cast steel.

Welding Metallurgy. *Edited by A. L. Philips. American Welding Society, New York. 1960. Paper, 6 by 9 in., 122 pp. Price $2*

This condensed textbook of ferrous and nonferrous welding metallurgy was reprinted from the latest edition of the *Welding Handbook* and should prove valuable for all training programs where the fundamentals of welding metallurgy are involved. The handy booklet covers temperature changes in welding, structure of metals, mechanical properties of metals, fracture in metals, factors affecting weldability, and all common metals and alloys.

Organometallic Chemistry. *Edited by H. Zeiss, Reinhold Publishing Corp., New York. 1960. Cloth, 6¼ by 9¼ in., 549 pp. Price $17.50*

The first major work on organometallic chemistry in over a decade, this book presents an authoritative survey of recent developments in carbon-metal compounds.

Among the topics covered by 14 leading authorities are: carbon-metal bonding, benzyne chemistry, vinylmetallics, organoboranes, organoaluminum compounds, organosilylmetallics, cyclopentadienyl metal compounds, arene complexes of the transition metals, transition metal alkyls and aryls, and metal carbonyls and related compounds.

Unfired Pressure Vessels: The ASME Code Simplified. *Robert Chuse. F. W. Dodge Corp., New York. 1960. Cloth, 6 by 9 in., 154 pp. Price $8.75*

This simplified guide to the ASME Boiler and Pressure Vessel Code covers basic causes of accidents and failures, corrosion and stress failures, design pitfalls, welding procedure, effects of welding heat, and weld inspection. The book is an attempt to simplify the work of designing, building, ordering, repairing, and inspecting pressure vessels.

Reports

Properties of tantalum INVESTIGATION OF THE PROPERTIES OF TANTALUM AND ITS ALLOYS. *F. F. Schmidt and others. Battelle Memorial Institute. Mar '60, 112 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.50 (PB 161758)*

The effects of alloying elements on the properties of tantalum were investigated in an effort to develop tantalum-base alloys that can be used as aviation structural metals at temperatures above 2000 F. The report points out that tantalum offers the unusual combination of excellent fabricability and high melting point, but exhibits only moderate strength properties and has poor oxidation resistance at high temperatures.

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TECHNICAL LITERATURE

Several alloying elements were found to be effective in reducing both scaling and contamination.

Ablation materials DETERMINATION OF FACTORS GOVERNING SELECTION AND APPLICATION OF MATERIALS FOR ABLATION COOLING OF HYPERVELOCITY VEHICLES. *J. H. Bonin and others, Chicago Midway Laboratories, University of Chicago. Feb '60, 162 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D.C. Price $3 (PB161702).*

Heat transfer characteristics of 52 different materials, evaluated by subjecting them to the high temperature plasma discharge of an air-stabilized electric arc. Specimens of various compositions cast in the same shape were subjected to heat fluxes at 600 and 1950 Btu/ft²-sec.

Metallurgy and ceramics *Available from Office of Technical Services, Dept. of Commerce, Washington 25, D.C.*

The following studies for the Atomic Energy Commission in the fields of metallurgy and ceramics are now generally available:

HIGH TEMPERATURE CORROSION STUDY INTERIM REPORT FOR THE PERIOD NOVEMBER 1958 THROUGH MAY 1959. *July '59, 38 pp, $1.25 (AECD-4292).*

DEVELOPMENT OF CORROSION RESISTANT NIOBIUM-BASE ALLOYS. *May '60, 90 pp. $2 (BMI-1437).*

A STUDY OF THE HIGH TEMPERATURE AIR OXIDATION OF YTTRIUM METAL. *Mar '60, 32 pp, $1 (IS-VV5).*

EFFECT OF HEAT TREATMENT ON THE CORROSION OF ZIRCONIUM. *Jan '60, 13 pp, 50¢ (KAPL-2071).*

DEVELOPMENT OF FERRITIC STEELS FOR HIGH TEMPERATURE SODIUM SERVICE. *May '60, 33 pp, $1.25 (NAA-SR-4832).*

AQUEOUS CORROSION OF THORIUM ALLOYS AND ZIRCALOY-CLAD THORIUM ALLOYS. *Mar '60 49 pp, $1.25 (NMI-1226).*

MULTI-TEMPERATURE EXTRUSIONS. *Mar '60, 49 pp, $1.25 (NMI-1229).*

CORROSION OF ZIRCONIUM ALLOYS IN 900 AND 1000 F STEAM. *Mar '60, 25 pp, 50¢ (NMI-1235).*

Properties of semiconductors INVESTIGATION OF PHYSICAL PROPERTIES OF SEMICONDUCTORS. *Available from Dept. of Commerce, Field Services, 350 Fifth Ave., New York 1, N. Y. Price $1.50*

Solid solutions and compounds of various metals and tungsten trioxide were investigated to find materials having semiconducting prop-

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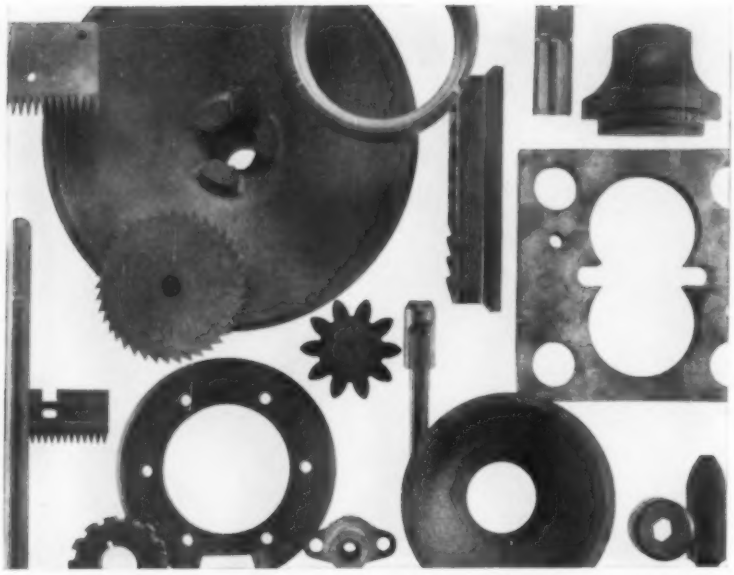

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TECHNICAL LITERATURE

erties at high temperatures. Copper tungstate and a compound containing a small amount of silver in tungsten trioxide were found to have interesting properties. Aluminum boride was found to be a semiconductor with a large activation energy.

High strength molybdenum DEVELOPMENT OF HIGH STRENGTHS AND HIGH RECRYSTALLIZATION TEMPERATURES IN MOLYBDENUM-BASE ALLOYS. *M. Semchyshen and others. Climax Molybdenum Co. of Michigan. Feb '59, 116 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.75 (PB 161542)*

A group of wrought molybdenum-base alloys were evaluated to determine amenability to available working processes, anticipated high recrystallization temperatures, and high strength properties. Castings were converted to bar stock and examined for recrystallization temperature, grain growth and embrittlement tendencies, tensile and creep-rupture strength, and brittle-to-ductile transition.

Oxidation of tungsten OXIDATION OF TUNGSTEN AND TUNGSTEN-BASE ALLOYS. *E. A. Gulbranson and others. Westinghouse Electric Corp. Feb '60. 86 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.25 (PB 161709)*

The oxidation of pure tungsten and its alloys was investigated at temperatures up to 1600 F under a wide range of oxygen pressures. Kinetic studies were made on sheet and wire specimens at temperatures from 930-2370 F over a broad pressure range.

Protective coatings PROTECTIVE COATINGS FOR REFRACTORY METALS. *C. G. Bergson and others. University of Illinois. Jan '60, 50 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.25 (PB 161736)*

Ceramic coatings consisting of admixtures of zirconia and glass provide oxidation protection for tungsten wire in an oxygen-free environment at temperatures up to 3600 F for as long as 3½ hr.

NEED DATA on refractory metals? See M/DE's *Materials Selector* issue (mid-Nov '60) for physical, mechanical and fabricating properties; corrosion resistance; available forms; suppliers; and typical uses.

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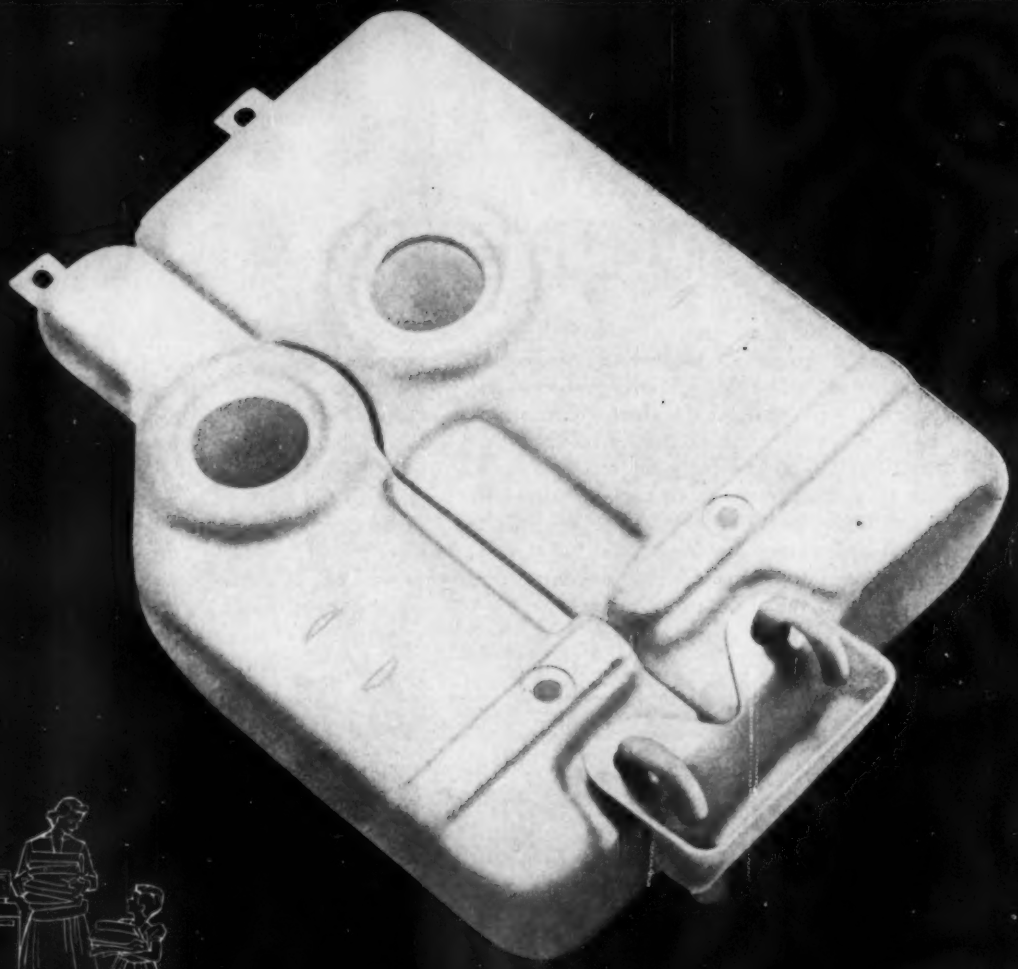

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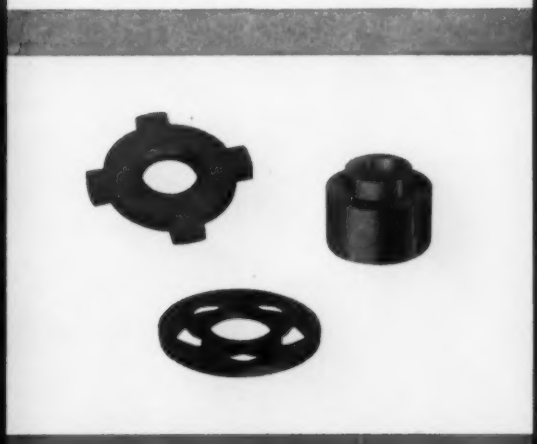
GRAPHITAR air/oil seals employed in today's high-speed turbojet engines have established an enviable record for operating dependability. Installed on the main shaft of the turbine, GRAPHITAR seals successfully withstand tremendous shaft speeds and generated heat.

GRAPHITAR bearings in the power reactor pumps of American nuclear submarines have compiled an outstanding record for dependability.



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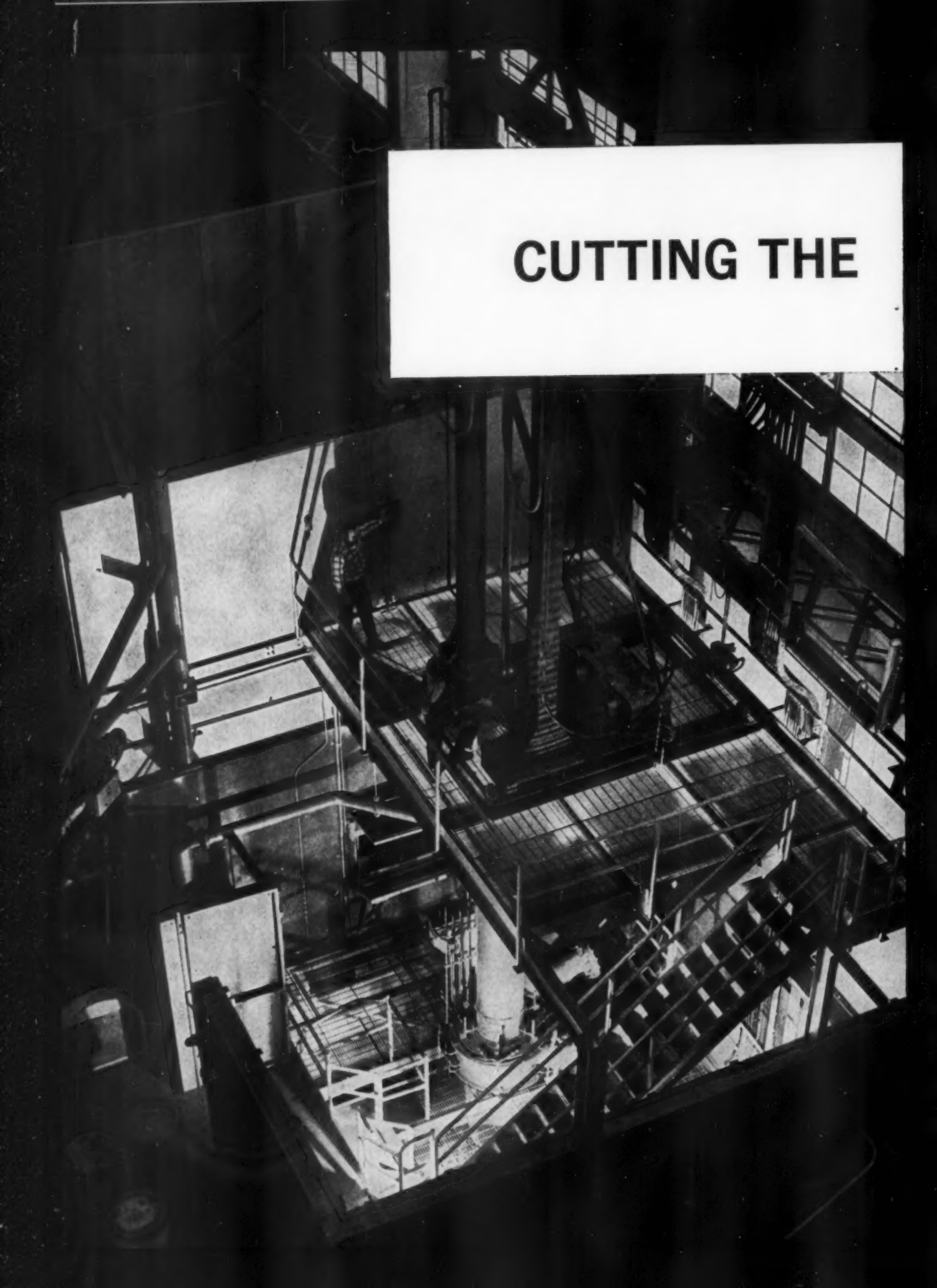

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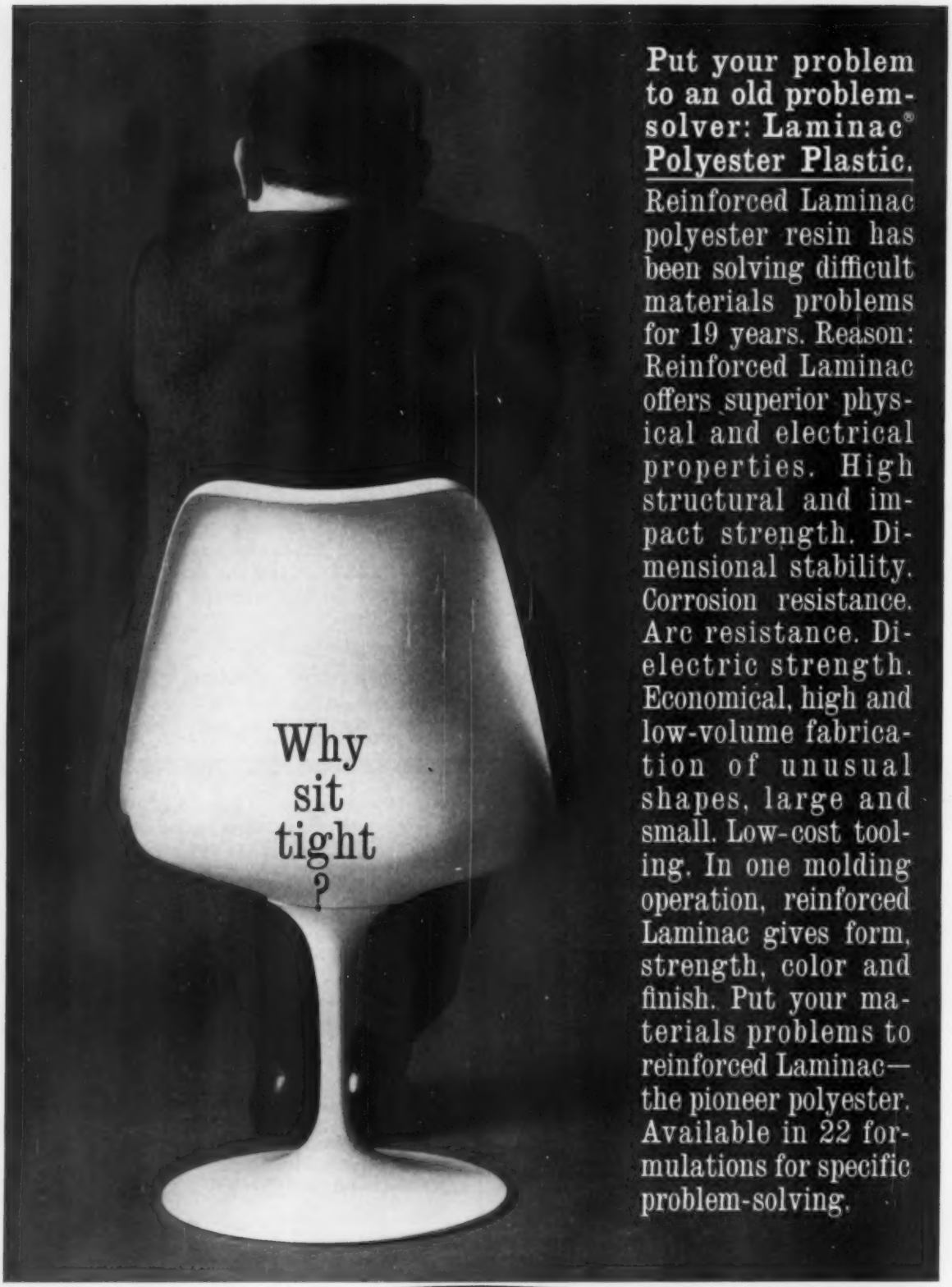

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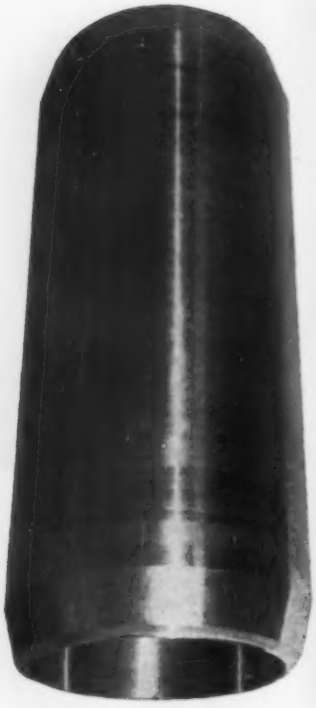

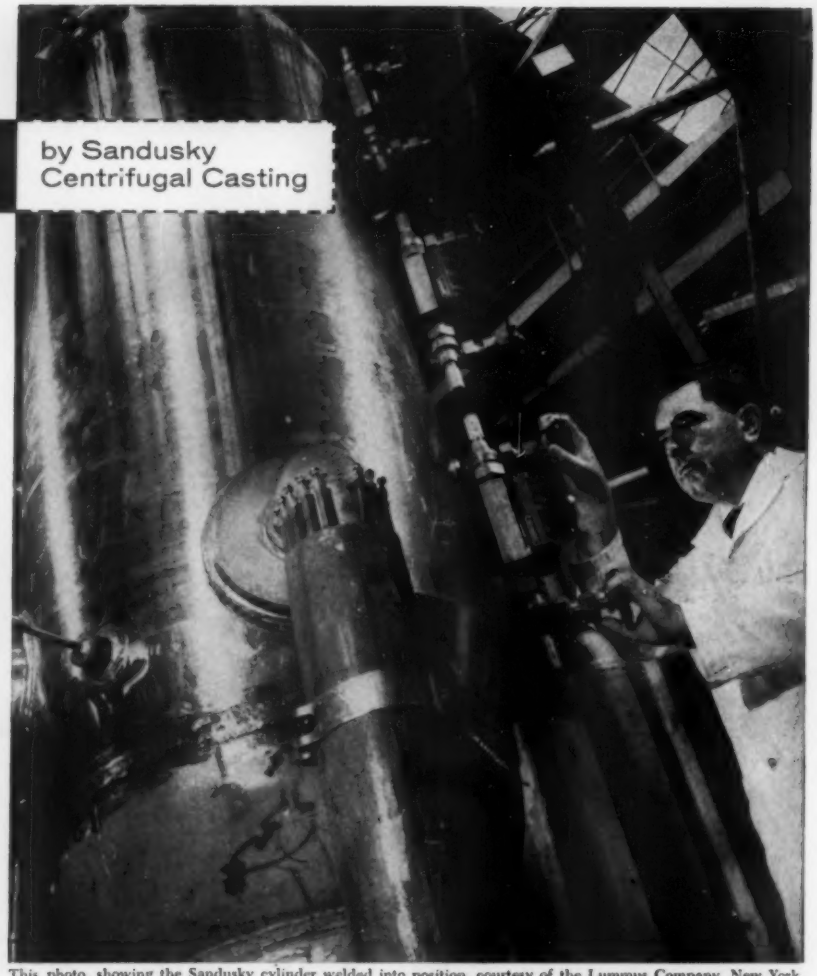

This photo, showing the Sandusky cylinder welded into position, courtesy of the Lummus Company, New York. New York who fabricated, assembled and tested the completed loop before shipping it to the ETR site in Idaho.

Nuclear Test Loop Uses Sandusky Centrifugal Casting as Pressurizer Cylinder

A Sandusky Centrifugal Casting is the main cylindrical component of an electrically heated pressurizer, designed by Knolls Atomic Power Laboratory to Section VIII, of the ASME Code (Unfired Pressure Vessels) for use in the new Engineering Test Reactor facilities at Idaho Falls, Idaho.

This 66¼" long cylinder, 27" O.D. with walls 2½" thick, was centrifugally cast of an 18-8 stainless steel (SA-351, Grade CF-8) for the extra corrosion resistance required under nuclear loop service conditions: demineralized water at temperatures to 650°F and pressures to 2500 PSI.

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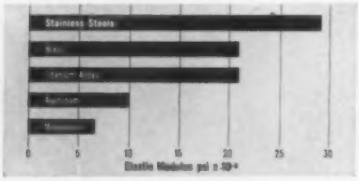
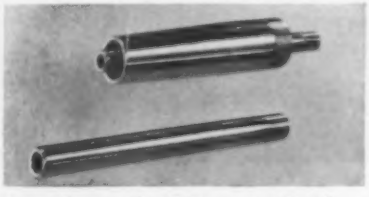
This advertisement is one of a series on the advantages of Carpenter Stainless Steel. As a handy reference for material selection, these data can pave the way for successful results on your next assignment.

Higher elastic modulus



The elastic modulus of an alloy is one of the most important properties used in the design of springs, fasteners, diaphragms and many other components subject to stress in service. Materials with a high modulus deform very little under load; materials with a low modulus may be completely unsatisfactory because of excessive dimensional change. Stainless steels with a modulus of about 29 million psi., are ideal for use in such structural components particularly when either corrosion or heat resistance is also needed. The chart above shows the elastic modulus of materials sometimes considered for such applications.

Better corrosion resistance

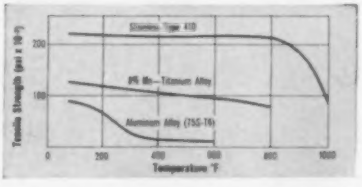


A good example of Carpenter Stainless resistance to corrosion. The nozzles used to fill storage batteries with electrolyte were formerly made from hard rubber. These rubber nozzles did not corrode, but they broke frequently, and proved costly to replace. After switching to Carpenter Stainless No. 20Cb, all problems were solved. No breakage . . . no corrosion . . . more production per shift. The perfect choice of material for this highly corrosive application.

Increased productivity

Big results in miniature . . . with Carpenter Mel-Trol® Stainless No. 440-C. Ten of these miniature precision bearings laid side by side measure only one inch in length! A miracle in close tolerance machining was required to fabricate the race and ball retainers for these bearings. Since a change to Carpenter Mel-Trol No. 440-C, this manufacturer has realized a 200% increase in production. A big improvement for a small item.

Elevated temperature properties



Much of the newer industrial and military equipment is being designed for service at temperatures higher than ambient but not high enough to justify the use of the special high temperature alloys, for example, the maximum operating temperatures of 400 to 800°F. Alloys other than stainless steels have been considered for such applications but from both an economic standpoint and the stress requirements, one of the stainless steels is usually found to be the best selection as indicated in the chart above.

Application engineering service

To help improve stainless steel performance on almost every application, Carpenter has placed in the field this extra service for all its customers. Armed with skill and technical know-how, each Carpenter Representative is available for ideas and suggestions to improve the products you are contemplating. His vast knowledge of new products, plus application guidance and practical assistance can be of great help to you. Get in touch with the Carpenter Representative nearest you. You'll find him a good man to have on your team.

Additional help

Space does not permit a complete listing of description and application suggestions for all grades of Carpenter Stainless Steels. For detailed information on all grades of Carpenter Stainless, write today for the Technical Data Sheets available upon request.

Are you getting all these performance characteristics in the materials you specify?

- ☐ *brilliant finish*
- ☐ *maximum strength*
- ☐ *corrosion resistance*
- ☐ *uniformity*
- ☐ *hardness*
- ☐ *versatility*
- ☐ *good machinability*
- ☐ *ease of fabrication*
- ☐ *exacting tolerances*
- ☐ *long service life*
- ☐ *customer satisfaction*

Carpenter Stainless gives you *all* these . . . and more!

Carpenter steel

you can do it ***consistently*** better with Carpenter Stainless Steels for specialists

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

For more information, turn to Reader Service card, circle No. 423

Where can this FLEXIBLE, clear, plastic tubing fit into your plans?

TYGON

✔ If you convey corrosive gases and liquids.

✔ If you convey liquid food products.

✔ If you require flexible lines with solution visibility.

Chemically-resistant, non-toxic, supple as a fly line, Tygon clear flexible plastic tubing is the ideal medium for those tough-to-solve piping problems.

Possessing a flex life ten to twelve times that of rubber, free of aging characteristics, Tygon serves equally well as a permanent component in machines or as quickly assembled and disassembled, temporary or permanent plant piping.

QUICK FACTS

Eight standard formulations to meet a wide range of requirements.

Special formulations for unusual needs.

More than 66 standard sizes ranging from 1/16" to 4" I.D.

Available if desired with outer braid reinforcement for pressures up to 300 psi.

THIS FREE BOOK TELLS THE COMPLETE STORY

Address:
Dept. MDE-361
Plastics and Synthetics Division
The U. S. Stoneware Co.,
Akron 9, Ohio
Ask for Bulletin T-97

Plastics & Synthetics Division

U. S. STONEWARE
AKRON 9, OHIO

353E-3

For more information, turn to Reader Service card, circle No. 428

FOR THE MACHINERY PART

THAT TAKES THE BEATING

A cut-off knife made of HAYNES STELLITE alloy No. 19 slices through molten glass at 2200 deg. F. Despite the intense heat of the glass being molded into tumblers, and the severe erosive action of the glass on metal, the cut-off knife maintains a 0.015-in. clearance between itself and the mold ring . . . *far longer than any other material ever used.*

Are you looking for a tough metal part to improve your machinery? It will pay you to look into HAYNES alloys. There are more than 15 from which to choose, including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. Parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist many conditions of wear, heat, or corrosion.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

HAYNES STELLITE COMPANY

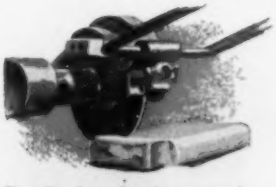
Division of Union Carbide Corporation

Kokomo, Indiana

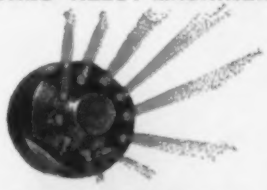
UNION CARBIDE

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY MACHINERY PARTS



Tough, long-lasting metal-cutting saws over 20 inches in diameter, made of HAYNES STELLITE alloy sheet, slice the tops off copper ingots.



Steam atomizer fuel burner nozzles of HASTELLOY alloy C resist corrosive agents and erosion for months, retaining essential contours.

High-temperature strength and corrosion resistance of diesel combustion chambers made of HASTELLOY alloy C make them "good for life of the engines."

For more information, turn to Reader Service card, circle No. 382

Joe Foster, President, indicates possible new applications for Nylon-6.

"Your competitors may be switching to Nylon-6 righ · now," says Joe Foster

Could be. It's worth thinking about.

For one thing's sure—Nylon-6 is one of the great molding resins, one that's bound to be popping up before long in exciting new applications. In portable electric mixers, maybe. Or transistor radios. Or electric shavers. Or even power tools.

But Nylon-6 should be part of your thinking for *several* reasons. Not just because of what your competition may or may not be planning, but because of what this remarkable fabricating material itself has to offer—a *unique combination* of advantages. Colorability. Non-flammability. Ease of molding and extrusion. Strength. Toughness. Abrasion-resistance. Impact-resistance. Flexibility. Heat stability. Self-lubrication. *And* the extra merchandisability of "Nylon" adds magic sales-power to all types of products.

As the world's largest manufacturer of sunglasses (with Nylon-6 frames) and a leading resin producer, we have great confidence in Nylon-6. That's why we recently acted to speed new applications, by reducing the price of Fosta® Nylon—our Nylon-6—to 98 cents a pound in quantity.

Like to find out more about Nylon-6? We'll be glad to send you current literature on Fosta Nylon. Just call us at KEystone 4-6511 or write Foster Grant Company, Inc., Leominster, Mass.

Your Partner in Plastics Progress

FOSTER GRANT

Plants in Leominster, Mass., Manchester, N. H., Baton Rouge, La.
Branch Offices and Warehouses in Principal Cities
Also distributed by H. Muehlstein & Co., Inc., New York, N. Y.

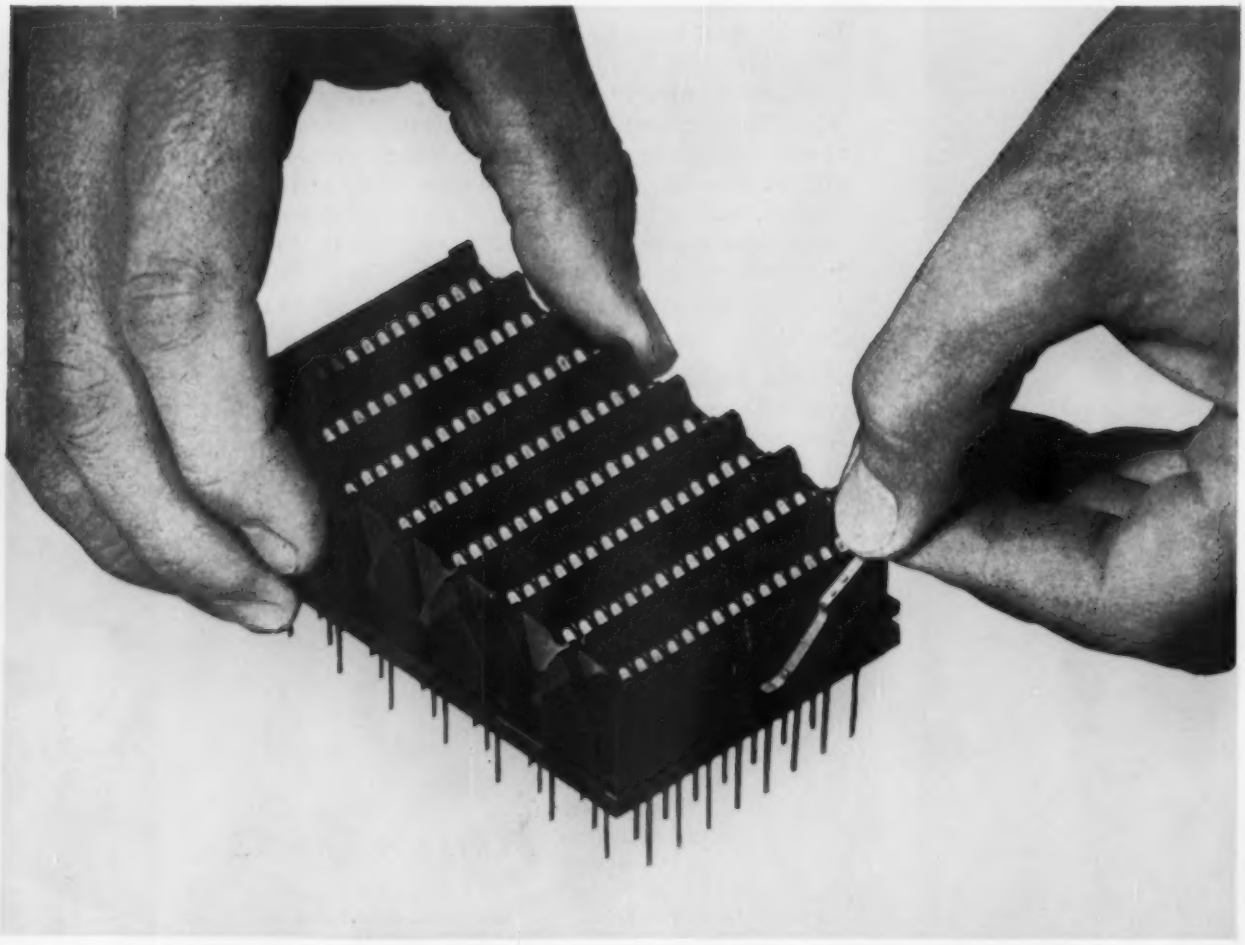
For more information, turn to Reader Service card, circle No. 440

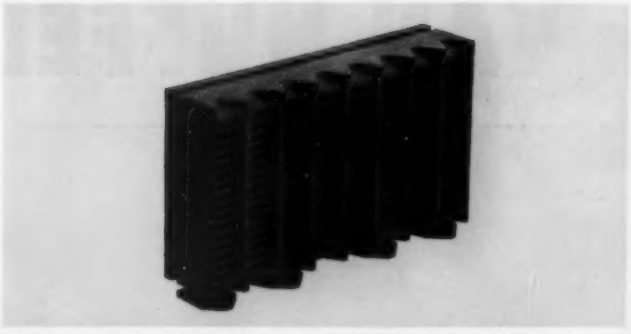
SYLVANIA PRODUCES & DELIVERS THE COMPLETED ASSEMBLY

—at substantial savings to IBM

This electrical connector block is a vital link in the electrical system of an IBM computer. Unless it is built to exact tolerances, the computer can malfunction.

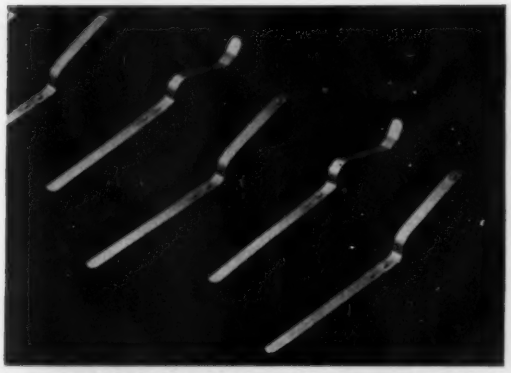
To make this critical part, IBM chose Sylvania because we could perform the entire production sequence—from raw materials to completed assemblies built to tolerances in terms of thousandths of an inch. It soon proved the Sylvania experience paid off in two ways: in production economies and in fast delivery too. Total result: a better connector block—at lower cost. (For details see captions to pictures on these pages.) For full information on how Sylvania custom facilities can benefit *you*, or for a quote on a specific project, write Sylvania Electric Products Inc., Parts Division, Warren, Penn.





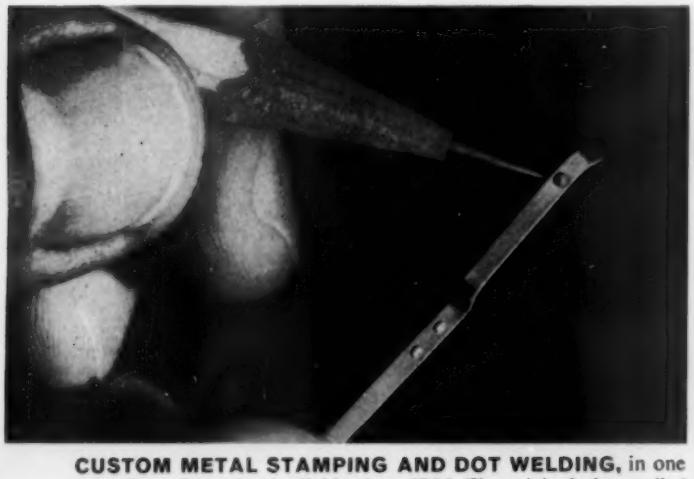
MOLDED FROM PLASTIC by Sylvania, the IBM connector block meets tightest specifications. This is possible because Sylvania maintains one of the world's most modern and complete lines of automatic molding equipment. This equipment permits Sylvania to handle volume orders for compression, injection and transfer molding. And a unique bank of rotary presses can produce millions of precision parts each day—even using phenolics and urea.

Result to IBM? Precisely formed parts to fill high-volume requirements.

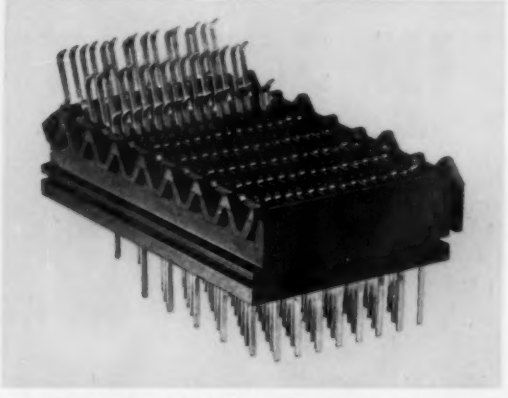


MADE FROM SYLVANIA WIRE, precision-rolled ribbon connectors offer high reliability when the circuitry is completed using wire wrap contact methods. The cross section of the ribbon—.023″ x .062″—and the corner radius of .003″ were accomplished on a special three-head tandem rolling mill and special forming equipment.

Result of this flexibility to IBM? Top reliability at close tolerances.



CUSTOM METAL STAMPING AND DOT WELDING, in one operation, also paid big dividends to IBM. The original plans called for forming parts and then gold-plating the entire contact. Following a request by IBM to extend contact life and reduce costs, Sylvania experience paid off. Sylvania Engineers demonstrated they could weld a tiny gold dot at the contact point economically while maintaining close tolerance on the critical dimensions of the formed contact. High-speed, high-volume techniques enable Sylvania to meet critical deflection and sheer tests. Sylvania maintains a metal stamping facility which includes multi-slide machines, vertical presses, and specially developed machines to help solve your special problems.



CUSTOM ASSEMBLY by Sylvania of the block and the parade of contacts is handled by our corps of trained specialists. Many of our customers have found that Sylvania can often deliver completely assembled and packaged products—using either all Sylvania components or all customer components, or both—*at lower cost than is possible in the customer's own facilities.*

Result to IBM? Many, many thousands of completed top-quality assemblies per month, and to tolerances specified for automatic wire wrap.

QC SERVICE MEANS QUALITY CONTROL!

At Sylvania, a tough-minded, hard-to-please quality control department has full authority for assuring the parts Sylvania produces meet your most stringent specifications. Example of this thoroughness: for the IBM connector block, Sylvania used *100% inspection!*

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

For more information, turn to Reader Service card, circle No. 441

New...from VAN HUFFEL

COLD FORMED CONTINUOUS

SINGLE WELD

STEEL TUBING IN RECTANGLES AND SQUARES IN SIZES THIS

BIG

FOR INDUSTRIAL AND ARCHITECTURAL APPLICATIONS

Steel

WHERE BIG IDEAS TAKE SHAPE IN METAL

APPLICATIONS

Because of its high production potential and adaptability, the uses of Van Huffel square and rectangular tubing are practically unlimited. Here are a few:

Structural Columns
Sign Supports
Canopy Supports
Beams
Steel Buildings
Farm Equipment
Earth Moving Equipment
Bridge Work
Automobile Transports
Storage Racks
Guard Rails

ACTUAL SIZE
6" x 6" .259 WALL

ADVANTAGES

MORE STRENGTH
Roller Die, cold formed continuous welding *on one side* **ONLY** provides maximum strength throughout.

GREATER SAVINGS
High strength-to-weight ratio permits use of lighter gauges or smaller sizes than solid metals.

UNIFORMITY
Uniform wall thickness, square sides, accurate radii and straightness.

FUNCTIONAL BEAUTY
Smooth finish, free of scale and protruding flash, ready to paint.

STANDARD SIZES AND GAUGES

Squares:
5" x 5" — .165" to .259 wall
6" x 6" — .165" to .259 wall

Rectangles:
4" x 6" — .165" to .259 wall
4" x 8" — .165" to .259 wall
in any lengths and all common grades of steel.

ACTUAL SIZE: 4" x 8" .259 WALL

Van Huffel also produces this wide range of standard welded sizes and gauges:

ROUND: ⅜" thru 6" in gauges from .020 (25 ga.) thru .259 (3 ga.) and all intermediate sizes.

SQUARE: ⅜" thru 6" in gauges from .020 (25 ga.) thru .259 (3 ga.) and all intermediate sizes.

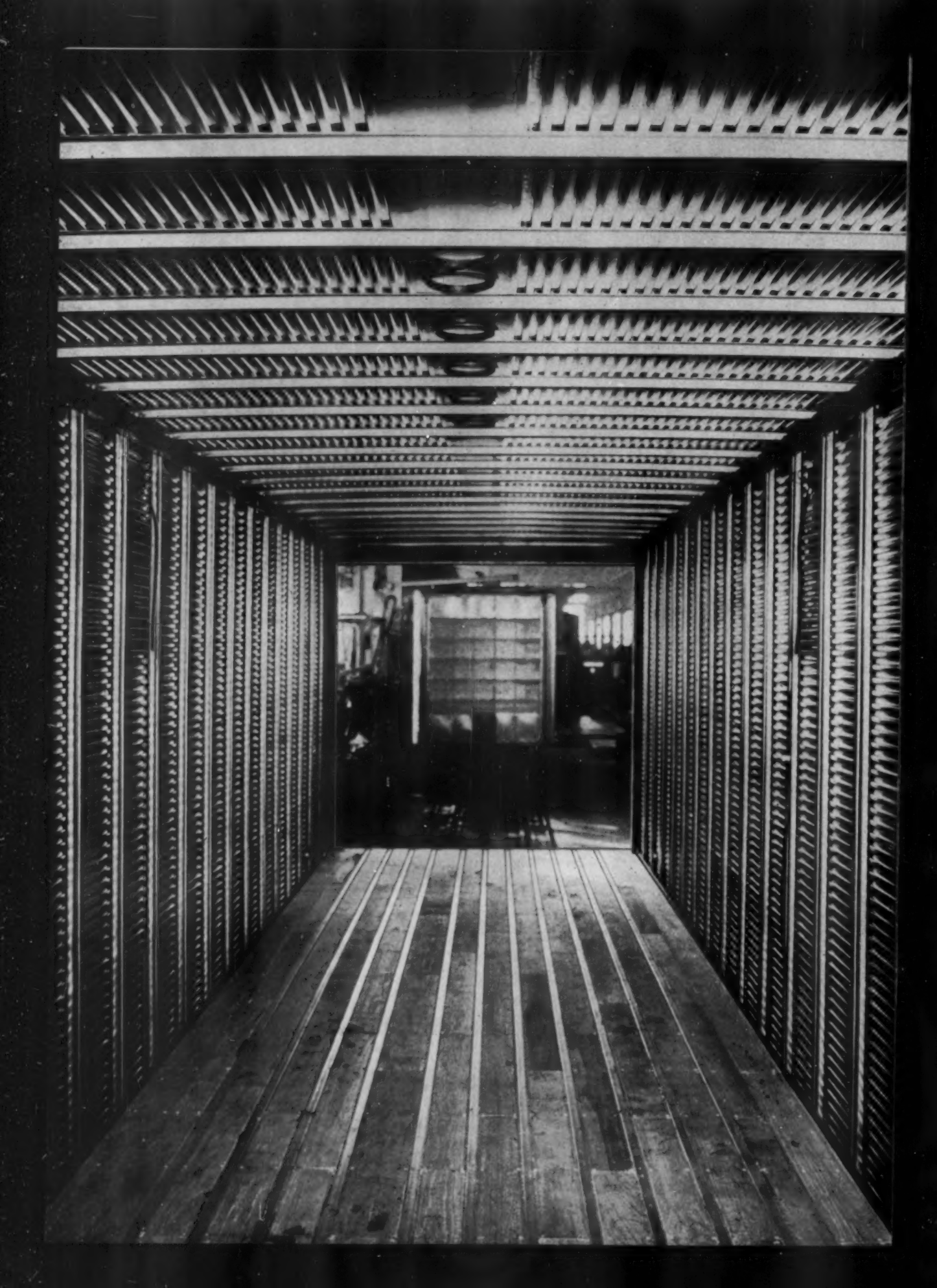
RECTANGULAR: ½" x ⅜" thru 4" x 8" in gauges from .020 (25 ga.) thru .259 (3 ga.) and all intermediate sizes.

All Van Huffel Welded Tubing stocks are available through Steel service centers in principal cities.

WRITE FOR FREE 48 page handbook

VAN HUFFEL
TUBE CORPORATION • WARREN, OHIO

For more information, turn to Reader Service card, circle No. 433



MECHANICAL PROPERTIES*

	YOLOY E HSX	YOLOY E HS	YOLOY E ACR
Carbon, max. %	.18	.18	.10
Manganese, max. %	1.00	1.00	.60
Phosphorus, max. %	.09	.10	.05
Sulphur, max. %	.05	.05	.05
Silicon, max. %	.30	.30	—
Copper %	.20/.50	.20/.50	.25/.50
Nickel %	.40/1.00	.40/1.00	.60 max.
Chromium %	.20/.60	.20/.60	.35 max.
Yield point, psi	45,000 min.	50,000 min.	45,000 max.
Tensile Strength, psi	80,000 max.	70,000 min.	60,000 max.
Elongation in 2", %	25.0 av.	.22 min.	30.0 av.

*Mechanical properties for Yoloy E steels up to ½" in thickness.

ADDITIONAL TYPICAL MECHANICAL PROPERTIES

Ultimate compressive strength: equal to tensile strength.
Ultimate shearing strength: equal to ¾ of tensile strength.
Modulus of elasticity, psi_____29,000,000

ASTM STANDARD COLD BEND TESTS

½" thick and under shall bend 180° around pin whose diameter is equal to one (1) times thickness of sheet, plate or bar.
Over ½" thick shall bend 180° around pin whose diameter is equal to two (2) times thickness of the bar or plate.

FABRICATING PRACTICE FOR COLD FORMING

THICKNESS OF PRODUCT	YOLOY E HS SUGGESTED MINIMUM INSIDE RADII	YOLOY E HSX SUGGESTED MINIMUM INSIDE RADII
up to 1/16" inclusive	1 x thickness	1 x thickness
Over 1/16" to 1/4" inclusive	2 x thickness	1½ x thickness
Over 1/4" to 1/2" inclusive	3 x thickness	2½ x thickness

YOLOY

high strength steel lasts longer, weighs less, does more for you per mile, per load

Youngstown's Yoloy E steel is brawny, durable, with up to 40% more strength than ordinary steels. It lasts longer, is easier to form, weld, use. It has up to 6 times more corrosion resistance. Even paint adheres better.

Cars, trucks and trailer bodies of rugged low-cost Yoloy E are strongest per pound, most economical per mile on roads, today. The nation's big trucking firms know this and make it pay off for them in performance.

Get the proved longer service, easier fabrication and assembly, the economy of remarkable Yoloy E steel. Choose from 3 different types, each made to fit your special requirements: Yoloy E HSX, Yoloy E HS, and Yoloy E ACR.

Yoloy steels are a product of Youngstown integrated steel-making where quality and delivery are rigidly controlled from mine to open hearth to high-tensile cut plate and coiled sheet. For your high strength steel needs, choose Yoloy, one of over 800 quality steels from Youngstown.

Youngstown – growing force in steel

For more information about Yoloy Steel, write: Department Z-31.
The Youngstown Sheet and Tube Company, Youngstown, Ohio

For more information, turn to Reader Service card, circle No. 399

URETHANE FOAM...
a basic engineering material with the right combination of property and application advantages

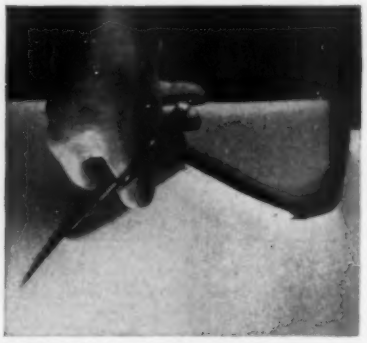
TOUGH! Tear strength up to 8 psi; tensile strength up to 40 psi; may be stretched to 500% of original length without parting.

STRONG! Urethane foams have been flexed at 30 cps at 30-80% deflection for 3,000,000 cycles with minimum property loss.

CHEMICALLY STABLE! Urethane foams are unharmed by dilute acids, alkalies, detergents, water or dry cleaning solvents.

LIGHT WEIGHT! At 2 lbs. pcf, properties of urethane foams are superior to other foams weighing twice as much.

SOFT! An entirely new experience in cushioning effect. You will have to *feel* urethane foams to understand the growing preference for these materials in cushioning markets.



VERSATILE! Urethane foams may be sliced, sawed, sewn, stapled, glued, sprayed or foamed in place, die-cut, flocked, laminated, tufted, contour-cut, with standard fabricating equipment.

Here's a versatile engineering material that will enable you to convert designer's dreams into manufacturing realities with a minimum of time, cost or experimentation.

If you have a design or engineering problem requiring a highly functional material for cushioning, insulating, void filling or padding, urethane foam might be the answer.

Write Mobay for detailed technical information and sources of supply.

MOBAY CHEMICAL COMPANY
Dept. MD-11
Pittsburgh 5, Pa.

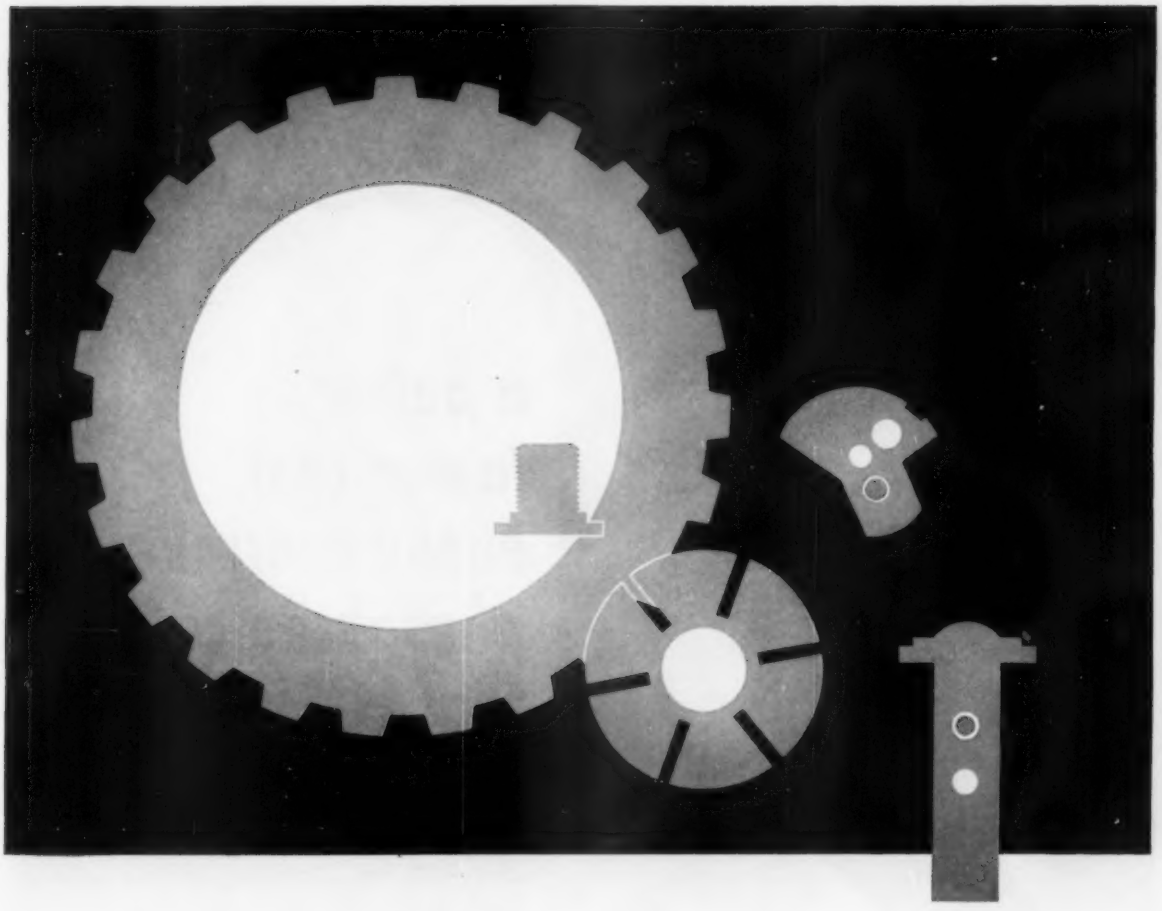
☐ Please send literature on flexible urethane foams
☐ Please have representative call on me.

Name ..... Title .....
Address .....
City ..... State .....

Mobay is the leading supplier of quality chemicals used in the manufacture of both polyether and polyester urethane foams.

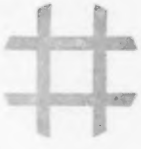
MOBAY
First in Urethane Chemistry

For more information, turn to Reader Service card, circle No. 425



Better metal parts . . . at lower cost . . . through METAL POWDERS!

Once limited to the production of a few specialized items, the powdered metal process is today established as a standard technique throughout industry. Manufacturers have discovered that components may be turned out in fewer man hours, with less material waste . . . and with greater precision. In addition, powder metallurgy provides the tool designer the freedom to create unique structures impractical to produce by any other method.



Metals Disintegrating Company will supply any manufacturer, anywhere in the world, a specific grade of powder in aluminum, tin, copper and other metals and alloys in a wide range of particle sizes. Our complete laboratory and testing facilities are at your disposal to help you select the grade and material for your product.

METALS DISINTEGRATING COMPANY
Division of American-Marietta Company
General Offices, Department X, Elizabeth B, N. J.

For more information, turn to Reader Service card, circle No. 424

INTERLOX...

a better, lower cost, easily controlled phosphate coating that LOCKS your finish to the metal.

Interlox's unusual cleaning ability and radically different type of accelerator produce an even, fine grained, dense coating that literally locks an organic finish to the metal.

Interlox gives you the ultimate in appearance, adhesion and corrosion resistance—no streaks, stains, powdery residue or flash rusting to complicate your production. Interlox baths are unusually long lived and require less replenishment and control.

Extra cleaning power is easily obtained at any time by the addition of a low-cost detergent only. This avoids the danger of over-phosphatizing by the costly practice of adding complete phosphatizing compound when only cleaner is needed.

There is an Interlox product to meet your particular requirements, whether spray or immersion type, single or multiple stage.

Licensed Manufacturers { **Alert Supply Co., Los Angeles, California**
Armalite Company, Ltd., Toronto, Canada

NORTHWEST CHEMICAL COMPANY
9310 ROSELAWN • DETROIT 4, MICHIGAN
CHEMICAL PRODUCTS DIVISION • CHEMETRON CORPORATION

For more information, turn to Reader Service card, circle No. 431

Zero burnout time
and minimum "haloing"
are combined in CDF's new grade 614 glass fabric epoxy laminate at no increase in price over conventional NEMA G-10 grades. Available plain or copper-clad, 614 is a cold punch material that is also superior in flame retardancy, has excellent trichloroethylene vapor resistance and low moisture absorption. The grade is distinguished by its opacity and its tan color.

Result: Another example of CDF leadership in meeting critical military and industrial applications while effecting important customer savings!

Typical properties of 614 (1/16" thickness):

Burnout Time, sec.	0
Water Absorption	0.10
Flexural strength, psi, lw	75,000

(Copper-clad 614 meets MIL-P-13949B, Type GF Plain meets NEMA G-10; approval pending for MIL-P-18177B, Type GEE. Also pending under NEMA proposed FR-4)

CDF CONTINENTAL-DIAMOND FIBRE

CONTINENTAL-DIAMOND FIBRE CORPORATION, NEWARK, DELAWARE • A SUBSIDIARY OF THE Bird COMPANY

TubeXperience in action

STST*

*Superior Tool Steel Tubing

ODDS: 1000 TO 1 TO CUT COSTS, IMPROVE PERFORMANCE IN 1001 DIFFERENT APPLICATIONS

Superior tool steel tubing is an excellent material for tools, but equally good for 1001 other applications. Odds are that it will cut costs and improve performance wherever it is used. Type E-52100, an oil hardening grade of high-carbon and chromium alloy steel, has been widely used for such diverse applications as thread guides on hosiery knitting machines, nylon yarn guides, ball bearing races, nozzles for blast cleaning equipment, gear and pinion parts, dental instruments and extrusion mandrels. Type E-1095, a high-carbon steel tubing, is serving as applicators for jewelers' oilers, leather and paper punches, and surgical instruments.

Perhaps you have an application that can benefit from high strength and hardness, good wear resistance, abrasion resistance, shock resistance, and notch toughness. In that case, consider Superior tool steel tubing before you go any farther. It could give you a better product at a lower cost. Send for Data Memorandum #14, a handy guide to your thinking. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Steel

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

For more information, turn to Reader Service card, circle No. 323

Escon®

POLYPROPYLENE

GIVES YOU A BALANCED COMBINATION OF PROPERTIES...

When you take *all* the facts into consideration, you'll discover that Escon polypropylene gives you unusually high performance at low cost.

And, Enjay has complete commercial fabrication equipment to help solve your processing problems.

For technical assistance, write to Enjay at 15 W. 51st Street, New York 19, New York.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY PLASTICS

For more information, turn to Reader Service card, circle No. 459

LOOK WHAT YOU CAN GET FROM

Lever support hardened and oil impregnated for lifetime self-lubrication.
Braking plate for washing machine metal infiltrated and oil hardened for high strength and hardness.
Shock absorber rod guide steam treated for wear resistance.
Power steering pump thrust plate requiring no secondary machining.
Gear and pin assembly brazed together during metal infiltration.
Automotive front suspension bearing carbonitrided for wear resistance.

DELCO MORAINE SINTERED METALS NOW:

Characteristics peculiar to sintered metal place it in a unique position in the metal forming industry. It provides a way to form shapes which are impractical to form by any other means. It permits combination of metals and non-metals which cannot be combined by other processes. It makes possible controlled density or controlled porosity, a fact significant in certain applications. Sintered iron and steel lend themselves to special processes if the application requires special hardness or strength.

Which of these will make sintered metal useful to you?

OIL HARDENED PARTS

Ferrous sintered metal with sufficient combined carbon can be oil hardened to a particle hardness of R_C55 minimum. In addition to the increased wear resistance obtained by hardening, controlled porosity and self-lubrication are retained.

STEAM TREATED PARTS

Iron base materials may be subjected to steam at an elevated temperature to effect controlled surface hardening and sealing. The surface is economically coated with a hard, tight film of wear-resistant black iron oxide.

METAL INFILTRATED PARTS

Certain parts are infiltrated with a copper base alloy to obtain high tensile and compressive strength. Machinability and modulus of elasticity are improved. Separate pieces may be brazed together during this process.

CARBONITRIDED PARTS

Iron base materials may be case hardened by the carbo-nitriding process. This results in a particle hardness of R_C60 minimum that provides maximum wear resistance. The full impact strength of the core is retained.

PRECISION PARTS WITHOUT MACHINING

When the design recommendations of Delco Moraine engineers are followed, many complicated structural parts may be readily manufactured in large quantities to exacting specifications without secondary machining operations. Reliability and consistency of the parts are inherent.

METAL INFILTRATED AND HARDENED PARTS

Parts which have been infiltrated may be oil hardened for those applications requiring extremely high strength, hardness, and wear characteristics.

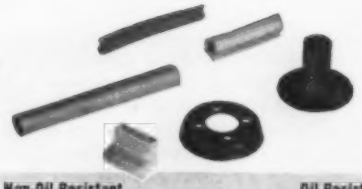
Our engineers are available to consult with you at any time and place about new developments and new applications for this basic process. Ask them to explain to you the economies of complex parts made from sintered metals.

DELCO MORAINE

Division of General Motors, Dayton, Ohio

For more information, turn to Reader Service card, circle No. 384

RUBBER in Design Engineering



Garlock offers dozens of different types of rubber, each carefully chosen and processed to meet your exacting needs . . . natural rubber with high tensile strength where real "rubber-like" properties are required . . . styrene butadiene rubber, the work horse of the industry—a low cost material for use where a good, rugged general purpose compound is required . . . neoprene rubber where good oil and abrasion resistance and aging characteristics are important. In addition, Garlock offers a wide range of nitrile and butyl compounds where their special properties are required. For more difficult applications Garlock offers a complete line of specialty rubbers from silicone for high and low temperature service to VITON* for extreme temperature and solvent resistance.

	Non-Oil Resistant			Oil Resistant	
PROPERTIES	**Natural**	**SBR**	**Butyl**	**Nitrile**	**Neoprene**
Tear Resistance	Excellent	Poor-fair	Good	Fair	Good
Abrasion Resistance	Excellent	Good	Good	Excellent	Excellent
Compression Set Resistance	Good	Good	Good	Very good	Good
Permeability to Gases	Fair	Fair	Excellent	Very good	Very good
Aging (Sunlight)	Poor	Poor	Excellent	Fair	Excellent
Aging (Oxidation)	Good	Good	Good	Fair	Good
Aging (Heat, max. temp. F)	200	250	300	250	250
Solvent Resistance (Aliphatic Hydrocarbons)	Very poor	Very poor	Poor	Good-Exc.	Fair
(Aromatic Hydrocarbons)	Very poor	Very poor	Poor	Fair-good	Poor
Oil Resistance (Low Aniline)	Very poor	Very poor	Very poor	Fair-Exc.	Fair
Oil Resistance (High Aniline)	Very poor	Very poor	Very poor	Fair-Exc.	Good
Gasoline Resistance (Aromatic)	Very poor	Very poor	Very poor	Fair-good	Fair
Gasoline Resistance (Non-aromatic)	Very poor	Very poor	Very poor	Good-Exc.	Good
Cold Resistance (Min. svc temp. F)	—65	—70	—65	—65	—50

This table gives you an idea of how some rubbers react to various conditions. In designing, consult your Garlock rubber specialist to achieve best application results.

Thoroughly tested to meet ASTM standards. Over twenty various tests are conducted on rubber materials before, during, and after manufacture to assure top performance. First, the rubber is carefully compounded and mixed exactly to specification. Then it is measured for durometer hardness, tensile strength, elongation . . . resistance to water, weather, temperature . . . many other vital characteristics. Scientific measurements like this, using ASTM, SAE-ASTM, and military standards—plus quality control during manufacture—assure you of the finest rubber parts available.

No two rubbers are alike. Each has its own individual strong points; each performs better under one set of conditions than another. In the design stage, call in your Garlock representative. He's a specialist in rubber parts and will assist you in selecting the proper material. Then, too, he may have several cost-saving ideas to suggest. You

GARLOCK

can reach him at the nearest of the 26 Garlock sales offices and warehouses throughout the U. S. and Canada. Or, write for Catalog AD-167, Garlock Inc., Palmyra, N. Y.

Canadian Div.: Garlock of Canada Ltd.
Plastics Div.: United States Gasket Co.

Order from the Garlock 2,000 . . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*Du Pont Trademark

For more information, turn to Reader Service card, circle No. 445

ASARCON

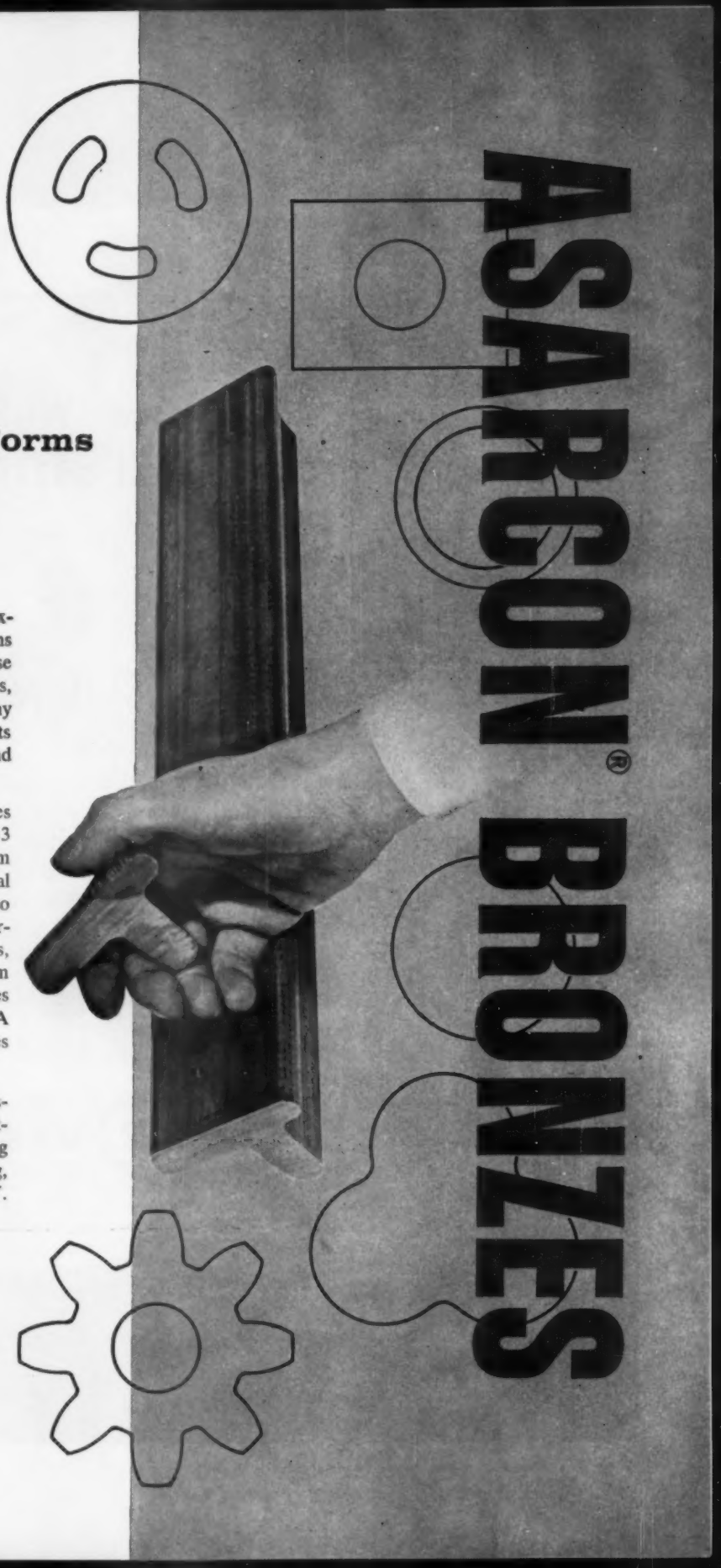
custom shapes and forms in any lengths you need

Asarcon continuous castings give you an extremely wide variety of shapes and forms in standard bronze alloys. They will increase your production rates and lower your costs, because: you get the shape you want in any length you need up to 20 feet. This permits machining on automatic screw machines and other high-speed equipment.

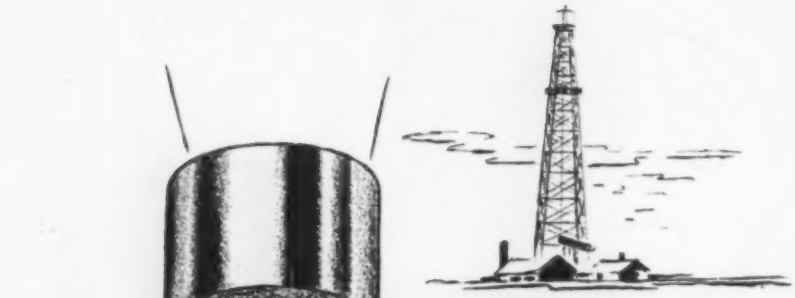
Continuous casting of Asarcon bronzes raises fatigue characteristics of standard alloys 33 to 100%, increases impact strength from 15% to more than double that of identical alloys cast other ways, adds materially to tensile, yield strengths and hardness. Asarcon 773 (SAE 660) bearing bronze in solids, rods and tubes is immediately available from stock in your choice of more than 260 sizes up to 9" O.D. and lengths up to 105". A wide variety of other special alloys, shapes and sizes produced to order.

For complete data on Asarcon continuous-cast bronze, write Continuous-Cast Department, American Smelting and Refining Company, Perth Amboy, N. J., Whiting, Ind.; or 120 Broadway, New York 5, N. Y.

ASARCO



For more information, circle No. 462



MUD was rough on oil drill nozzles!

Abrasion was causing hardened steel and even special alloy mud nozzles to wear out too fast. A metal exceptionally resistant to the scouring action of drilling mud was needed.

V-R CARBIDE solves the problem

Nozzles made of V-R carbide now far exceed the life of previously used metals. This is an example of creative engineering at Vascoloy-Ramet where metals are developed to meet physical specifications. Characteristics such as abrasion and corrosion resistance, dimensional stability, high density and strength are properties that are produced in varying degrees in V-R sintered or alloyed metals. Send us your specifications for your custom metal needs.

V-R

CREATING THE METALS THAT SHAPE THE FUTURE

VASCOLOY-RAMET

850 MARKET STREET • WAUKEGAN, ILLINOIS

A-827

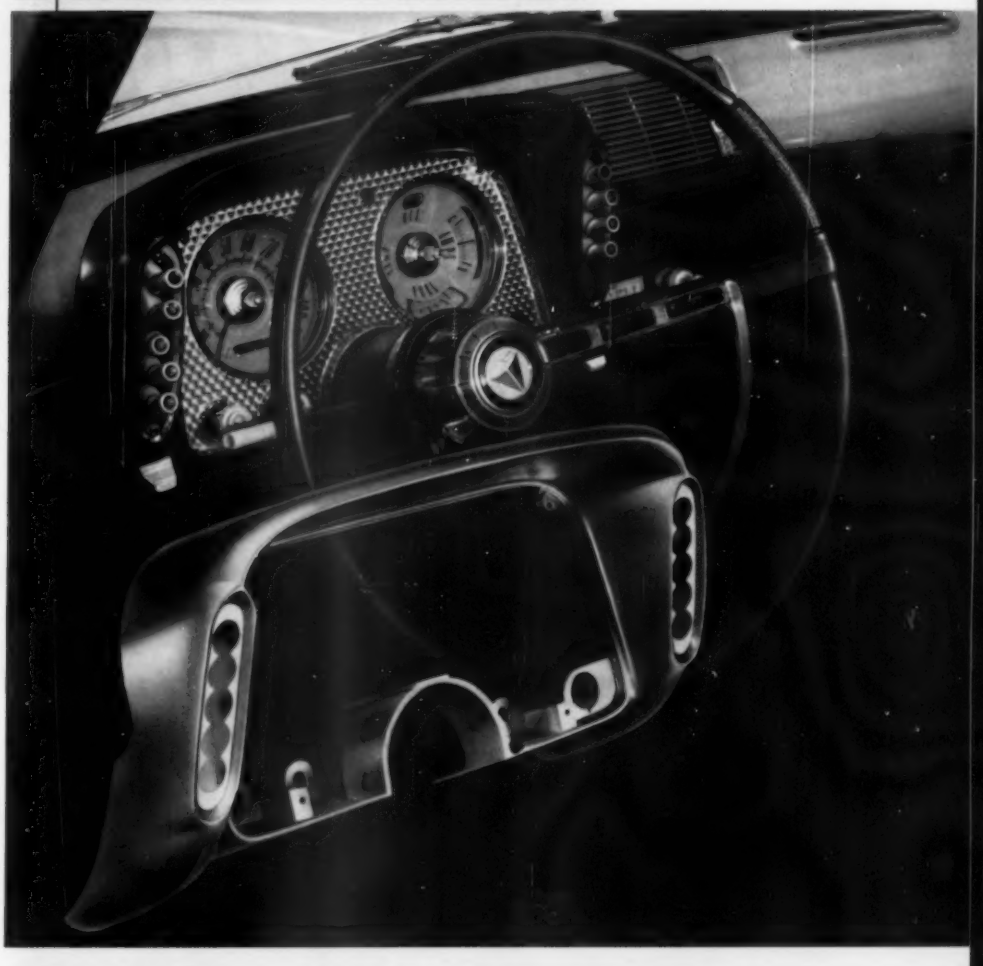
For more information, turn to Reader Service card, circle No. 421

For more information, circle No. 418 ➤

working with

Du Pont Delrin®

one of Du Pont's versatile engineering materials



New instrument housing of DELRIN® cuts weight 80%... simplifies assembly

In designing a compact automobile, weight reduction stands out among the objectives—less weight means improved fuel economy and easier handling. That's one of the reasons why Chrysler Corporation's 1961 Valiant has a one-piece instrument housing molded of Du Pont DELRIN acetal resin. At no sacrifice in performance, the use of DELRIN cuts the weight of the instrument housing by approximately 80%—from nine pounds in die-cast zinc to two pounds in DELRIN. This reduction not only pays off in lower over-all weight, but also eases handling on the assembly line.

The attractively styled housings of DELRIN have proved their durability through extensive road and laboratory tests. DELRIN offers strength in thin sections, even at elevated temperatures . . . remains dimensionally stable under varying conditions of humidity. Mounting of the housing is simplified because molded-in bosses accept self-tapping studs.

On the following page you will find more examples of the product improvements and savings in manufacturing and assembly costs made possible by DELRIN acetal resins in a variety of diverse fields.

DU PONT

REG U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING ... THROUGH CHEMISTRY

working with

Du Pont Delrin®

one of Du Pont's versatile engineering materials

The manufacturer of these valve components for check valves in water or gasoline pumping systems reports: "Severe testing proves that the disc retainer guide made of DELRIN is practically indestructible." Use of DELRIN instead of brass also prevents mineral build-up . . . eliminates the cause of valve sticking and faulty seating. (Molded by Holman Mfg. Co., for a division of Flomatic Corp., both of Hoosick Falls, N. Y.)

Shock absorber designed to eliminate water-hammer noises in residences has outer shell molded of tough Du Pont DELRIN. Reason for this choice: the shell of DELRIN is highly resistant to damage from residential shock pressures, exterior corrosion from most chemicals and water at 180°F. ("Genie" is molded for Josam Mfg. Company, Michigan, Indiana, by Stelrema Corp. of Gary, Indiana.)

A complete line of miniature oil-tight push buttons (colored buttons, rings and knobs) molded of Du Pont DELRIN to help provide easy identification. Designed for the toughest applications, these push buttons rely on the toughness, color variety, durability and wear resistance of Du Pont DELRIN acetal resin. (Manufactured by General Purpose Control Department of General Electric Co., Bloomington, Illinois.)

Parts of DELRIN® offer rugged, dependable performance under tough conditions

The strength, durability and dimensional stability of DELRIN acetal resin are particularly important when the part in question is subject to severe environmental conditions, such as high temperatures, moisture, solvent and many corrosive chemicals. In use after use, designers are continuing to find that DELRIN provides parts that will perform under these adverse conditions . . . plus substantial economies in manufacture and assembly. How about DELRIN for *your* product? Mail the coupon for further information.

POLYCHEMICALS DEPARTMENT

DU PONT

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)
Department I, Room 2507-D
Nemours Building, Wilmington 98, Delaware

I am interested in evaluating DELRIN for the following use:

_____

*Name*_____

*Company*_____ *Position*_____

*Street*_____

*City*_____ *Zone*_____ *State*_____

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

A

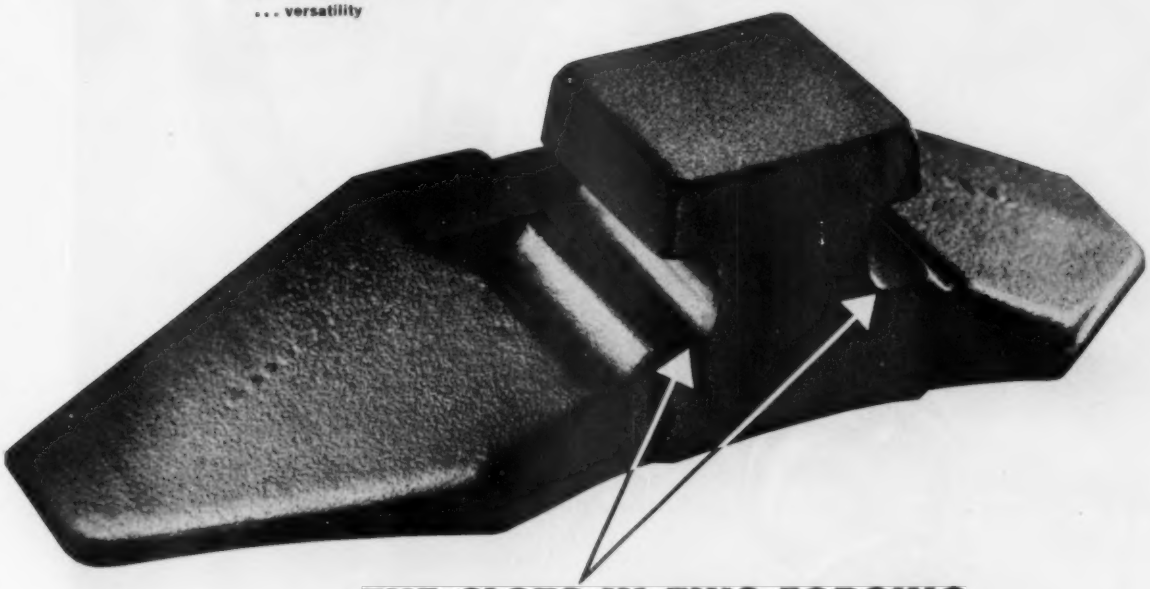
DELRIN® *acetal resins*

one of Du Pont's versatile engineering materials

Alathon® · Zytel® · Lucite®

Steel

For strength
. . . economy
. . . versatility



THE SLOTS IN THIS FORGING SAVED OUR CUSTOMER SEVERAL MINUTES MACHINING TIME

The slots in the part above used to be machined. That took time and tools. It was expensive—*needlessly*.

Now, at Bethlehem's suggestion, the forged part is trimmed along the parting line, then placed in a special fixture in the trimming press where the slots are hot-broached.

The hot-broaching involved a small additional tooling cost. But, now there's no more machining . . . No more wear and tear on machine tools . . . No more waste metal. Take our customer's word for it, his savings more than make up his slightly higher tooling costs.

Our sales engineers will be happy to take a fresh look at your forgings, to talk over your ideas and problems. Perhaps they can help you cut machining costs, too. We suggest that you get in touch with our nearest sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, circle No. 418

For more information, turn to Reader Service card, circle No. 375

New steels are born at Armco
Strong, hard, precision tube fittings
Ultra-strong jet engine mounts

Make harder, stronger corrosion-resisting parts at low cost with Armco 17-4 PH Stainless Steel

Use Armco 17-4 PH to give shafts, valves, fasteners and other critical parts this outstanding combination of properties:

High strengths. Up to 200,000 psi ultimate tensile strength; 180,000 psi yield strength. Good impact strength over a wide range of temperatures. High endurance limit and fatigue strength. **Corrosion resistance** comparable to Type 304 in many media. **High hardness** to solve wear, abrasion and corrosion-erosion problems. Good resistance to galling and seizing. Excellent mechanical properties to 900 F. Resistance to stress-corrosion cracking. **Cost-saving fabrication.** Short-time, low-temperature heat treatment permits finish-fabrication *first*. No distortion, no scaling, no cracking in hardening. Machinable 17-4 PH can also be upset, forged, swaged and welded.

Get full data

Complete data on 17-4 PH properties and fabrication will show where this unique special stainless may pay off for *you*. Call your nearest Armco Sales Office, your Armco Stainless Distributor, or fill in and mail the coupon.

Corrosion and wear-resisting homogenizer rotor

ARMCO DIVISION
Armco Steel Corporation
1011 Curtis Street, Middletown, Ohio

SEND catalog on Armco 17-4 PH Stainless Steel.

Name _____ Title _____

Firm _____

Street _____

City _____ Zone _____ State _____

This symbol on your products tells customers you use modern, long-lasting stainless steel.

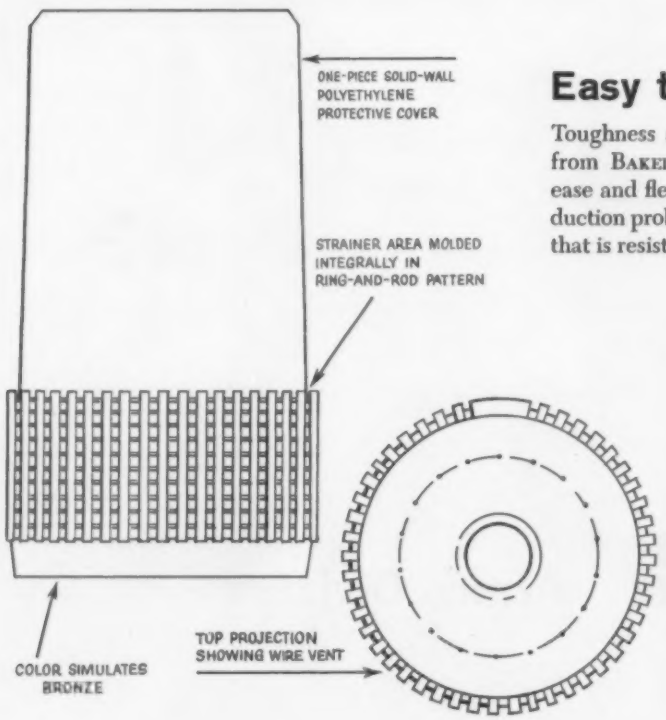
ARMCO Armco Division

For more information, turn to Reader Service card, circle No. 406

Nothing to Corrode in This Cover

One-piece molding provides neat, tight-fitting cover with no screws, bolts, or nuts to vibrate, work loose or corrode. Drainage water and chemical detergents have no adverse effect on this completely corrosion-resistant component.

END CORROSION DAMAGE...DESIGN


ONE-PIECE SOLID-WALL POLYETHYLENE PROTECTIVE COVER
STRAINER AREA MOLDED INTEGRALLY IN RING-AND-ROD PATTERN
COLOR SIMULATES BRONZE
TOP PROJECTION SHOWING WIRE VENT

Easy to Mold, Tough in Service

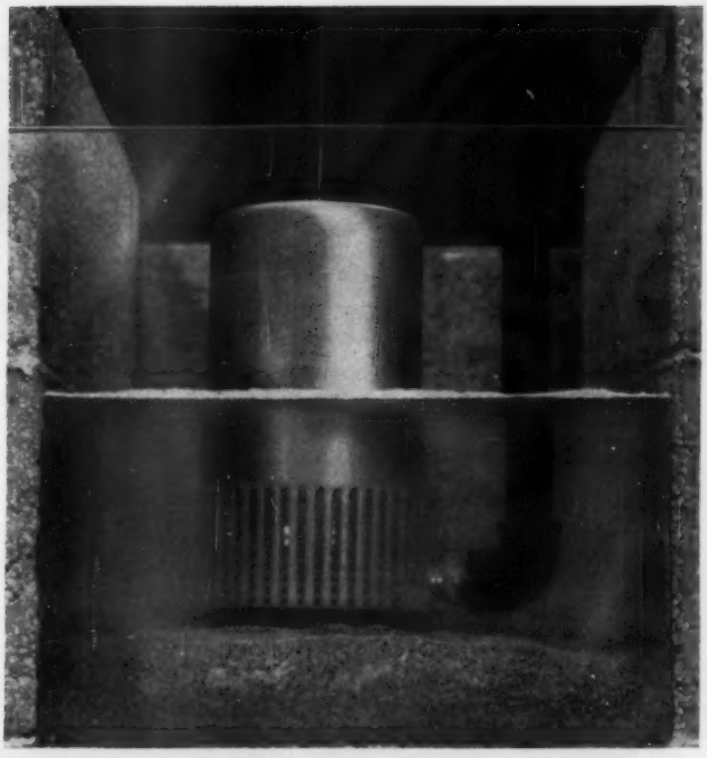
Toughness and rigidity are characteristics of parts molded from BAKELITE Brand high-density polyethylene. Molding ease and flexibility go far in eliminating many common production problems. Result: a durable, smooth-functioning part that is resistant to water and most common chemicals.

TYPICAL PROPERTIES OF DMD-6001

Properties	ASTM Test	Typical Value
Density, gm/cc	D 1505	0.950
Melt Index, gm/10 min.	D 1238	2.0
Tensile Strength, psi	D 638	3,400
Elongation, %	D 638	45
Secant Modulus (Stiffness), psi	D 638	100,000
Hardness, Durometer "D"	D 676	60

Strong Plastic Housing for Sump Pump

Fostoria Corporation's "Dynasumps," designed for rigorous underwater service, are housed in covers molded from BAKELITE Brand high-density polyethylene DMD-6001. The cover-strainers are deep-drawn molded in one piece by Haas Corporation.



WITH HIGH-DENSITY POLYETHYLENE

BAKELITE BRAND high-density polyethylene gives 100% corrosion resistance with strength and molding ease

Finding the right combination of properties needed in the product you're designing is made easier by the variety of BAKELITE polyethylene formulations now available. In addition to low, medium and high densities, you can choose one of the new polyethylene copolymers. Stress-cracking resistance, moldability, dimensional stability, toughness, flex life, rigidity—you can now specify the properties you require.

Polyethylenes are only one group of BAKELITE Brand plastics—the others are epoxies, phenolics, styrenes, and vinyls—from which you may select. To help determine the one you could use to your best advantage, call on the technical experience and know-how of UNION CARBIDE. Consult Sweet's Product Design File, section 2a/ui. Or just mail the coupon below.

UNION CARBIDE

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

Union Carbide Plastics Company (Dept. LC-85C)
Division of Union Carbide Corporation
270 Park Avenue, New York 17, N. Y.

Please send me information about BAKELITE Brand Plastics for Design, with emphasis on these properties:

The type of application being considered is:

NAME

FIRM NAME

STREET

CITY ZONE STATE

For more information, turn to Reader Service card, circle No. 451

FERROLUM's Inner Armor of*

LEAD

Withstands CORROSION

and Travel Punishment

Tank Car is held in vertical position when lead surface is applied to heads at Knapp Mills' Wilmington, Del. plant.

***Metallurgically-Bonded Lead Surfaced Steel Produced by Knapp Mills Inc.**

The lead surface of Ferrolum tank cars has been proven in corrosive service over millions of rugged rail miles.

Savagely corrosive cargo such as bromine rides the rails all over the U. S. in cars like these. The metallurgically-bonded lead armor has withstood years of pounding vibration, jolts and shocks encountered in freight train travel, without fatigue failure.

The wedding of lead to other metals opens new doors in the use of this versatile material. It has created a whole new family of multi-functional metals which use lead's unique characteristics for handling radioactive and corrosive materials. Combinations include lead metallurgically bonded to aluminum, copper, carbon steel, stainless steel and other nickel alloys.

Look Ahead With **LEAD**

ST. JOE

ST. JOSEPH LEAD CO.
250 Park Avenue, New York 17, New York

PB-174 THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

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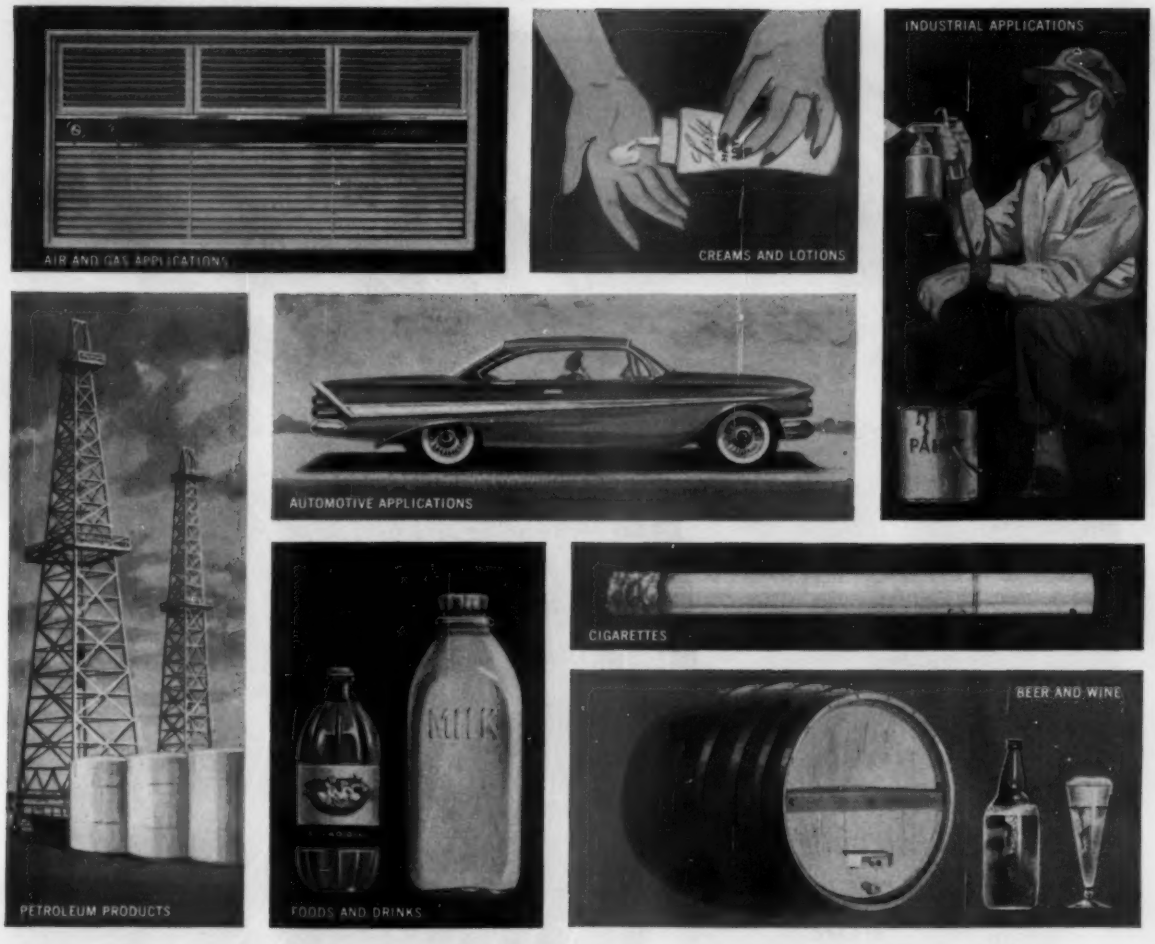
An example of Avisco Rayons in Industry



What do you want to filter better?

Many people who make or use filters are discovering that they can do a better job of filtering for less money with filters of Avisco® rayon. The diameter of man-made Avisco rayon fibers is so closely maintained that filter micron ratings can be held to meet most filtration specifications. So, whether you're interested in the filtering of liquid foods, oils, air, lacquers, paints, smoke, water, liquors or lotions—whether you are manufacturing filters by the wet or dry system—look into Avisco rayon fibers. Fill out and mail in the Quick Reply Coupon.

QUICK REPLY COUPON 7-4

Industrial Merchandising Division
American Viscose Corporation
350 Fifth Avenue, New York 1, N.Y.

Please contact me about Avisco Rayons for use in the following application:_____

Name_____

Company_____

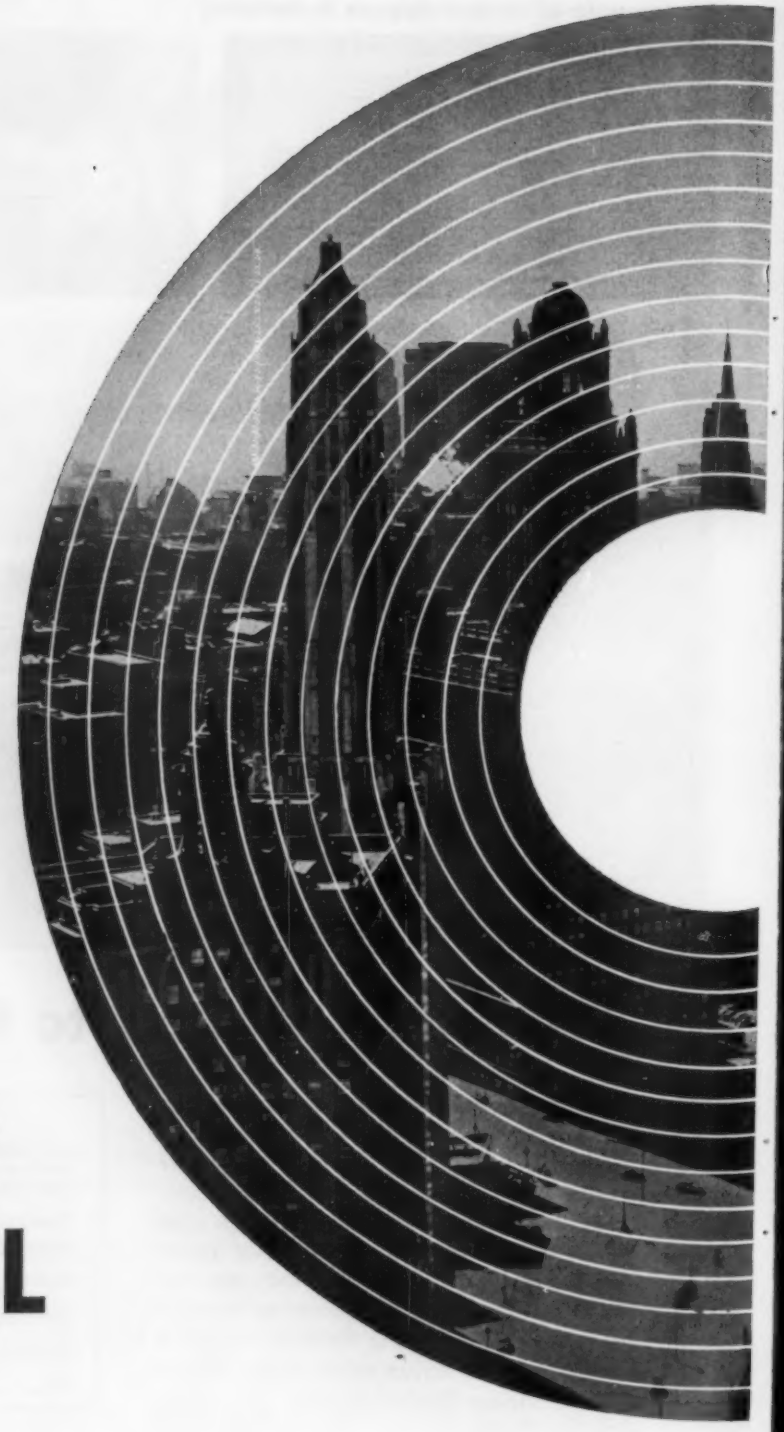
Address_____

City_____ Zone____ State_____

AVISCO® RAYON

AMERICAN VISCOSE CORPORATION, 350 Fifth Avenue, New York 1, N.Y.

For more information, turn to Reader Service card, circle No. 371



NOW
MORE
GALVANIZED
STEEL
FOR
MID-AMERICA
FROM
NEW

MIDWEST STEEL

For one of the greatest steel-consuming areas of the country, galvanized steel will now be in greater supply. The source is close, the service is fast, and the quality is second to none. Because

MIDWEST STEEL
Portage, Indiana

WEIRTON STEEL
Weirton, West Virginia

divisions of
NATIONAL STEEL CORPORATION

Weirkote, the modern continuous-process galvanized steel, is now being produced at our new Midwest Steel facilities in the Chicago area, as well as at our Weirton Steel division in the Pittsburgh area.

For more information, turn to Reader Service card, circle No. 326

Only one of sixty materials met these tough filter specifications

Troyfelt, a non-woven synthetic Dacron, gave best performance in military vehicle engine.

The specifications? Ability to produce nearly 100% filtering efficiency in heavy dust conditions, in temperatures from -65 to 275°F, resistance to oil, moisture, rot and mildew. The product? The filter on a heavy duty engine intake air cleaner on a military vehicle. The result? Out of sixty materials tested, only one, TROYFELT, did the job.

The secret behind TROYFELT'S success is its specialized manufacturing process of mechanically interlocking the Dacron, Orlon and other special synthetic fibers rather than chemically binding them or introducing binder fibers. This method eliminates the old filter "bugaboo" of blinding caused by such binders or binding agents and gives TROYFELT its unusually high, long-lived strength, excellent resistance to fungi and bacterial growth, chemicals, moisture, oil, abrasion, stability to temperature extremes and many others.

But, filtering is only part of the TROYFELT story — other applications for this remarkable material include insulators, seals, padding, packings, gaskets and many others. We'll be glad to send you our bulletin describing most of them and samples.

TROYFELT ... *by the pioneers in non-woven synthetic felts*

INDUSTRIAL PRODUCTS DIVISION • TROY MILLS, INC.

200 Madison Avenue • New York 16, New York

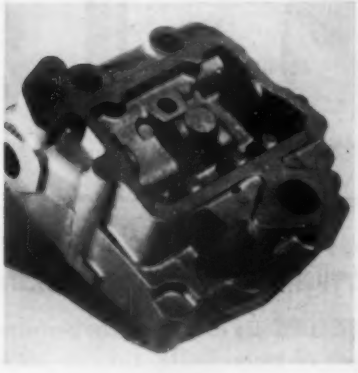
For more information, turn to Reader Service card, circle No. 455

PRODUCT-DESIGN BRIEFS FROM DUREZ

- Smooth surfaces in metal castings
- Plastic in luggage pods
- Fast facts on phenolics

Inside story

In an engine block such as this one, smoothness of the inner surfaces is a high-priority design problem. Any obstruction or undue roughness in the channels is likely to impede the flow of coolant through the block.

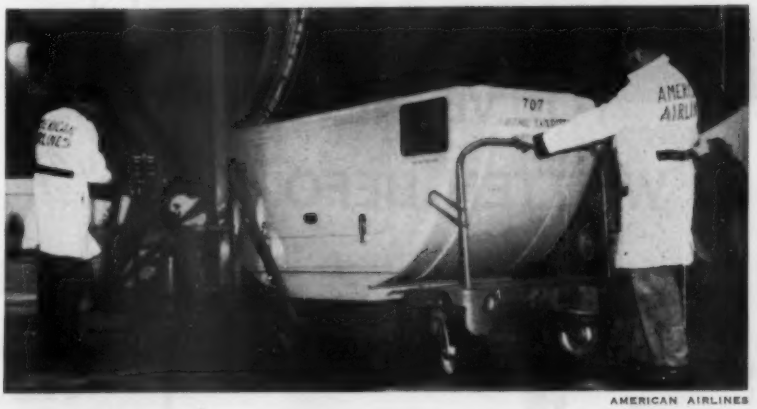


To solve the problem, more and more foundrymen are switching to a method of making castings that gives smooth, clean inner surfaces every time: shell cores.

They're getting more than smoothness. The close tolerances possible with shell cores permit holding section thickness uniform throughout the piece, and from piece to piece. In an engine block, that means better heat transfer.

Finally, most castings made with shell molds and cores need only a bare minimum of machining. That saves money.

Want to know how these better castings are made with the help of Durez foundry resins? Check the coupon and let us send you the new "Durez Guide to Shell Molding."



AMERICAN AIRLINES

It expedites

This pod shrinks time.

For people who have alighted from a jet airliner, it shortens the wait at the luggage checkout.

For the airline, it telescopes flight schedules by cutting ground time to the necessary minimum. For the men who use it to load or unload 35 suitcases at a crack, it takes much of the "lug" out of luggage.

It has to be strong, light in weight, safe. That's why it is made of Hetron® glass-reinforced polyester. Not only does Hetron match and excel the strength characteristics of other reinforced plastics; it is also inherently and *permanently* self-extinguishing. The safety is chemically locked in to stay—not obtained by dilution with additives.

Many great ideas like this one are taking shape in Hetron. They include 65-foot radomes, factory skylights, large boat hulls, outboard motor shrouds, chemical ducts and blowers, transformer housings, heavy-duty switch-gear components.

If you'd like to know more about this versatile, safe material—and who can mold it into shapes for you—check the coupon for the designer's Hetron data file.

At your finger tips

Here's the quickest way we know to compare one phenolic molding material with another. Just send for the new 16-page booklet "Facts on Phenolics." It groups the most popular Durez materials by types (general-purpose, impact, heat-resistant, electrical, etc.). It lists properties of the molding compounds and of molded specimens. It tells which MIL specs a compound is designed to meet. All you do is check the coupon to get a copy free.

For more information on Durez materials mentioned above, check here:

- ☐ Data file on Hetron, including list of fabricators
- ☐ "Durez Guide to Shell Molding" (36-page bulletin)
- ☐ "Facts on phenolics" (16-page booklet)

Clip and mail to us with your name, title, company address. (*When requesting samples, please use business letterhead.*)

DUREZ PLASTICS DIVISION

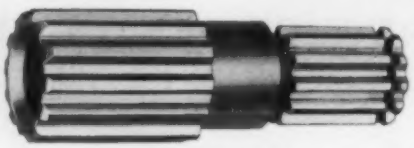
1403 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

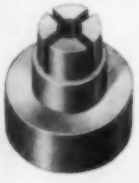
HOOKER CHEMICALS PLASTICS

For more information, turn to Reader Service card, circle No. 400

WRITE SPECS YOU'VE NEVER WRITTEN BEFORE!



Good Corrosion Resistance



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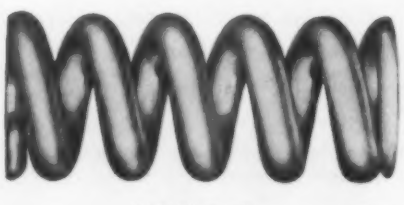

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ENGINEERING & DESIGN

...AT A GLANCE

Re-entering space capsules are being caught in mid-air with the aid of pressure-sensitive paper tape. The tape holds the metal grappling hooks and nylon harness onto the base of two trailing booms until the capsule's parachute is snagged. The tape is said to break consistently at the right instant to release the hooks from the booms so they hold the parachute until it is reeled into the plane.
Source: Minnesota Mining & Mfg. Co., St. Paul 6, Minn.

Containing the combustion gas flow has been the chief design difficulty in experimental magnetohydrodynamic (MHD) power generators. But the problem is being overcome by using a zirconium oxide insulation in the conduction tubes. Progress is also reported in overcoming this refractory's high electrical conductivity in the 4600 F operating range.
Source: Refractory—Zirconium Corp. of America, Solon, Ohio; MHD unit—Westinghouse Electric Corp.

Materials that can collect, store and convert solar heat to electricity for powering satellite circuits are the goal of a new research program sponsored by NASA. The thermal storage system will probably operate when the material is in a semi-liquid state. Silicon is said to represent the type material that will be studied.
Source: Missile and Space Vehicle Dept., General Electric Co., Philadelphia 4.

A small vacuum evaporation chamber recently developed by NBS permits a series of replicate electron microscope specimens to be prepared quickly and accurately without re-evacuating the chamber. The brass chamber, a 4.5 in. cube, can be used to shadow cast up to five specimens successfully during one evacuation.
Source: National Bureau of Standards, Washington 25, D. C.

A radiometer for measuring the earth's temperature from satellites weighs only 1.5 oz and is made almost entirely of polyester plastics. Polyesters were used in the two-channel unit mainly for two reasons: 1) they have good resistance to high-intensity, random vibrations, and 2) they are not subject to destructive degassing in outer space.
Source: Barnes Engineering Co., 40 Commerce Rd., Stamford, Conn.

A forged titanium bottle provides a pilot's emergency oxygen supply. The 3.5-lb bottle, made of 13V-11Cr-3Al titanium, is said to safely contain oxygen at 3000 psi. Forging this alloy was found to be the only way to provide the required strength and lightness.
Source: Wyman-Gordon Co., 105 Madison St., Worcester 1, Mass.

A molded acrylic plastic lens for a large marine buoy lamp doubles lamp efficiency and costs 80% less than its glass counterpart. The new lens is said to double either the candlepower or the battery life without increasing lamp size. Weight of the complete lantern assembly is only 20 lb—less than 10% of that of a glass lantern with the same output.
Source: Stimsonite Div., Elastic Stop Nut Corp. of America.

CMPC custom molds phenolic heat deflector for General Electric ranges

Certain models of General Electric's new line of Mark 27 built-in ranges are sporting an attractive CMPC-molded phenolic heat deflector. The 26-inch compression molded deflector, with a top continuous use temperature of 400 degrees F, is used to divert oven heat from the range control panel. By isolating controls from the effects of heat, the CMPC part helps insure longer, trouble-free service—something for which General Electric is famous.

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Stauffer Metals Co.

Fine grain structure *produced by electron beam melting (left) is compared with that resulting from arc melting (right). Metal is tungsten.*

Electron Beam Melting:

What It Does for Metals

by Donald Peckner, *Associate Editor, Materials in Design Engineering*

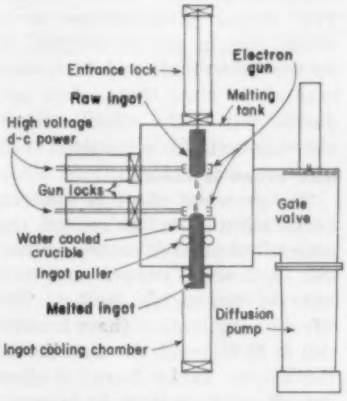
Here is the first comprehensive report on what this new way of melting means to engineers and designers. It includes property data for seven metals and alloys.

■ Although melting caused by electron bombardment has been known since the time of the early experimental work with x-rays, furnaces designed to take specific advantage of this technique have been in use only since 1958. The primary emphasis since then has been on technique. Experimental heats have been produced but little information has been made available on the properties of electron beam-melted metals and alloys.

This article will discuss the technique, and the purity of electron beam melted metals, in general terms. Primary emphasis, however, will be on the properties of metals and alloys melted by this technique. Seven metals are discussed: beryllium, hafnium, vanadium, tungsten, columbium, tantalum and cobalt.

The process

Use of an analogy may help to explain the principles underlying electron beam melting. A typical diode tube consists of an evacuated enclosure, a filament (cathode), and a plate (anode). The filament is heated electrically until it reaches a temperature at which the work function for electrons is exceeded; electrons begin to leave the filament surface with an initial velocity which depends on filament temperature. An electrostatic field is maintained between the tube elements, with the plate held positive relative to the filament. The emitted electrons are accelerated across this field and impinge on the plate.



***1**—Schematic diagram of the electron beam furnace and its circuitry.*
(Stauffer Metals Co.)

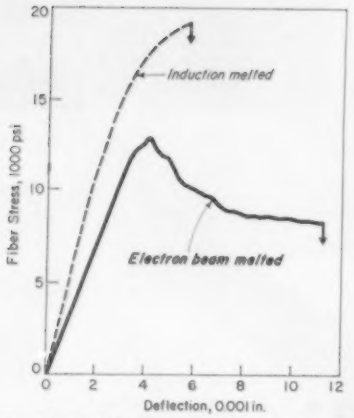
In this simple analogy as applied to electron beam melting, the plate represents the melt stock and the cathode is usually also a filament. An electrostatic field is maintained between the cathode and the melt stock by the power supply. Plate power cannot be dissipated as easily as in the diode tube because of the large number of electrons accelerated through the field. As a result, the melt stock is heated to the fusion point.

A schematic diagram of the electron beam furnace is shown in Fig 1.

. . . and its advantages

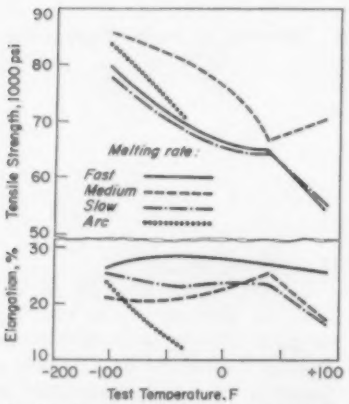
Three advantages of the electron beam melting process over conventional arc methods:

- Contamination is prevented and many impurities are removed by volatilization because of the high (0.1 to 0.01-micron) vacuum maintained during melting.
- Melt stock can be used in powder, flake, sponge or pressed bar form.
- Melting rate is easily controlled.



2—*Typical bend test results on arc melted and electron beam melted beryllium.*

(Sumsion and Matthews, OTS Rpt. PB 161327)



3—*Mechanical properties vs test temperature for electron beam melted vanadium. Data for arc melted vanadium are included.* (Reactive Metals, Inc.)

Two advantages common to both methods:

- Materials with very high fusion points can be melted.
- The cold crucible prevents contamination.

Although electron beam melting provides a means for producing very high purity alloys, it is not without several disadvantages. Basically, there are two:

- Because it produces a metal or alloy of higher purity (and greater ductility) than the vacuum arc process, the net result of electron beam melting is generally a weaker alloy.
- Elements such as chromium, titanium, vanadium and zirconium cannot be alloyed in large amounts with tungsten, columbium, tantalum and molybdenum. Reason: the vapor pressure of the former elements is higher than that of the latter ones and they would be lost, to some extent, by evaporation during melting.

TABLE 1—HARDNESS AND INTERSTITIAL CONTENT OF COBALT MELTED BY ELECTRON BEAM

Melting Method, Rate ↓	Composition, ppm[a]					
	C	N_2	O_2	H_2	Total	Bhn
Arc	136	100	220	6	462	150
Electron Beam						
Fast	51	21	140	7	219	154
Medium	71	25	280	10	386	153
Slow	60	29	310	5	404	172
Double Electron Beam						
Fast	54	26	240	5	481	156
Medium	56	15	120	4	195	135
Slow	64	—	170	4	—	131

[a]Each value is average of top and bottom analyses.

Source: WADD TR 60-404 (Reactive Metals, Inc.).

TABLE 2—INTERSTITIAL CONTENTS OF ELECTRON BEAM MELTED HAFNIUM

Melting Method, Rate ↓	C, ppm	O_2, ppm	N_2, ppm	H_2, ppm
Arc	82	440	85	175
Electron Beam				
Slow	149	360	26	22
Medium	114	140	15	27
Fast	105	170	27	9

Source: WADD TR 60-404 (Reactive Metals, Inc.).

The first disadvantage can be overcome by adding more of the nonvolatile alloying elements to achieve the effects of the lost interstitials and volatile metals. The second disadvantage is a minor one in the production of ductile columbium and tantalum-base alloys since these alloys are ductile only if the volatile metals are substantially eliminated.

How clean is clean?

The principal effect of electron beam melting is to reduce the interstitial element content (nitrogen, hydrogen, oxygen and carbon) of the metals melted. The effect of eliminating these impurities is to increase the ductility of the alloys. Tables 1 and 2 show the effect of electron beam melting on the composition of cobalt and hafnium.

Electron beam melting of tungsten also produces a high degree of purity in the finished material as shown below (figures in ppm):

Impurity	Starting Material	Finished Material
Carbon	30	30
Nitrogen	60	30
Oxygen	840	60

The data in Tables 1 and 2 show that some effect on removal of interstitials can be attributed to the rate of melting. The tables also show that degree of removal of undesirable elements must probably be determined for each material melted in electron beam furnaces. For example, carbon content of the cobalt melt was reduced from 136 ppm to 60 ppm, but no carbon was removed from the hafnium ingot. Similarly, while no oxygen was removed from the cobalt, oxygen content of the hafnium was reduced from 440 ppm in the arc melted metal to as low as 140 ppm in electron beam melted ingots. Nitrogen was readily removed from both metals.

Additions also help—Deoxidation of electron beam melts may be facilitated by the addition of metals which form oxides that are volatile, i.e., have a high vapor pressure. Data were obtained by Reactive Metals, Inc. on the effect of deoxidants on properties of beryllium, vanadium and molybdenum:

Molybdenum—Interstitial content of molybdenum was reduced by adding boron, thorium, yttrium, titanium and carbon. Boron appears to be the most promising deoxidizing agent. Adding 0.38% boron to molybdenum resulted in an electron beam melted ingot button which was rolled directly to sheet without prior working (such as forging or extruding). After a recrystallizing anneal, the sheet exhibited 19% elongation at 75 F.

Vanadium—Interstitial content of vanadium was not reduced by adding such deoxidants as yttrium, thorium and carbon. By using twice the stoichiometric amount of thorium (0.43%) needed for deoxidation, ductility of vanadium sheet can be maintained to —300 F, as shown in Table 3.

Beryllium — Although beryllium can be deoxidized by additions of yttrium, deoxidation had no beneficial effect on the ductility of extruded beryllium.

Properties of 7 metals and alloys

Mechanical property data for electron beam melted metals has not been extensively developed by users of the process. Many furnaces are being used on an experimental or developmental basis and the data are concerned with purity of the melt. The information presented here—in many cases for the first time—represents the most current compilation of mechanical property data for electron beam melted metals.

1. Beryllium

Because of its high volatile impurity content, beryllium bead could not be satisfactorily electron beam-melted. Rounds, which had been previously vacuum cast, were melted directly with no difficulty. In general, the appearance of ingots electron beam melted from vacuum cast rounds was superior to that of ingots melted from bead which had been consolidated by arc melting.

Effect of melting rate not clear —Melting rate can be varied from slow (2 in. per hr), to medium (6 in. per hr) to fast (12 in. per hr). The effect of melting rate on room temperature tensile strength, as shown in Table 4, is not clear. Beryllium bead, consolidated by arc melting and then electron beam melted, exhibited the highest value of tensile strength with the medium melting rate. Ingots prepared from vacuum cast rounds showed maximum tensile strength after the slow melting rate. The same relationship was true for room temperature elongation, but melting rate apparently had no effect on yield strength.

Elongation improved—At 750 F, the value of electron beam melting is obvious. Although yield and tensile strengths of arc melted and electron beam melted material are fairly uniform, elongation values increased from zero for the arc melted material to as high as 11% in 1 in. for electron beam melted beryllium.

Bend test results—Fig 2 gives bend test results both on induction melted and electron beam melted beryllium. A large amount of plastic deformation occurred in the electron beam melted specimens in spite of a premature partial failure. Failure probably occurred because of cleavage in an unfavorably oriented grain. In spite of this the crack did not propagate—an improvement in the crack propagation behavior of beryllium.

2. Hafnium

The effects of electron beam melting on the mechanical properties of hafnium are shown in

TABLE 3—EFFECTS OF DEOXIDANTS ON MECHANICAL PROPERTIES OF VANADIUM[a]

Deoxidant Added, % →	None	0.165 Y	0.33 Y	0.01 C	0.02 C	0.215 Th	0.43 Th
75 F							
Ten Str, 1000 psi	59	53	54	53	66	60	53
Yld Str, 1000 psi[b]	52	43	45	39	59	53	44
Elong, %[c]	19	15	22	18	16.5	20.5	25
—40 F							
Ten Str, 1000 psi	—	—	—	65	76	75	—
Elong, %[c]	—	—	—	10	9[d]	19	—
—100 F							
Ten Str, 1000 psi	78	71	74	69	80	82	72
Elong, %[c]	19.5	22.5	15	29	8[d]	3.5	20
—300 F							
Ten Str, 1000 psi	98	76	79	—	—	—	112
Elong, %[c]	0	0	0	—	—	—	7.5

[a]Annealed sheet 0.043 in. thk. [b]0.2% offset. [c]In 2 in. [d]Broke outside gage marks.
Source: WADD TR60-404 (Reactive Metals, Inc.).

TABLE 4—TENSILE PROPERTIES OF ELECTRON BEAM MELTED BERYLLIUM[a]

Melting Method, Rate ↓	68 F			750 F		
	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 1 in.), %	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 1 in.), %
Arc	33, 38	—	0	35, 36	—	0
Electron Beam[b]						
Slow	43	38	0.48	36	27	2.9
Medium	48	42	0.92	37	36	2.3
Medium	40	—	0.05	34	31	0.9
Fast[b]	19	—	0	34	—	0
Electron Beam[c]						
Slow	41, 47	40, 46	0.25, 0.28	34, 36	28, 29	1, 3
Medium	39, 42	—	0.05, 0.1	35, 43	29, 39	2, 5
Fast	29, 42	40	0, 0.3	36, 39	23, 24	6, 11

[a]Extruded and annealed. [b]Consolidated from bead then electron beam melted.
[c]Vacuum cast then electron beam melted.
Source: WADD TR60-404 (Reactive Metals, Inc.).

Table 5. Compared with electrorefined metal, electron beam melting seems to offer material with higher strength and lower ductility. Since electron beam melting usually results in increased purity, lower strength and higher ductility, the electron beam melted hafnium, in this case, may have a higher impurity content than the electrorefined hafnium. Metallurgical treatments are not similar and direct comparison is difficult.

3. Vanadium

Three electron beam melted ingots and one arc melted ingot of vanadium were conditioned and forged to ½-in. plate at 1800 F. The plates were then rolled to 0.040-in. sheet in an argon enclosure. This sheet stock was used to determine the mechanical properties listed in Table 6. The data are shown graphically in Fig 3.

Tensile strengths of the arc melted and electron beam melted vanadium did not differ greatly. Elongations at −100 F were also similar. At −40 F, however, elongation of the arc melted metal was lower than that of electron beam melted vanadium. Further direct comparisons cannot be made.

4. Tungsten

Work performed at Reactive Metals, Inc. on triple electron beam melted tungsten did not produce fabricable metal. Since the original work carried out at Reactive Metals, Stauffer Metals Co. has indicated that the use of additives (unspecified) and special electron beam processing techniques are required to produce a workable tungsten ingot.

The as-cast grain size of an arc cast tungsten ingot and one produced by electron beam melting of tungsten containing the unspecified additives are compared on p 101. A rocket nozzle forged from this type of fine grained tungsten is shown in Fig 4.

5. Columbium

Columbium can be alloyed in the electron beam furnace with tungsten, tantalum, molybdenum and, sometimes, small amounts of zirconium. Other metals, such as chromium and vanadium, are too volatile.

Generally, the maximum amounts of tungsten and molybdenum that can be added to columbium melts are 15% and 4%, respectively. Above these percentages it has been shown that the ductile-to-brittle transition temperature of the resulting alloys will exceed 500 F. Tantalum additions do not materially affect the impact properties of columbium. Oxidation resistance of columbium is reportedly improved by tungsten additions and by additions of tantalum up to 30 wt %.

Table 7 presents the room temperature mechanical properties of a series of columbium-base alloys. Unfortunately, it is not possible to directly compare the properties of these alloys with those of commercially available columbium al-

TABLE 5—MECHANICAL PROPERTIES OF ELECTRON BEAM MELTED HAFNIUM (Room Temperature)

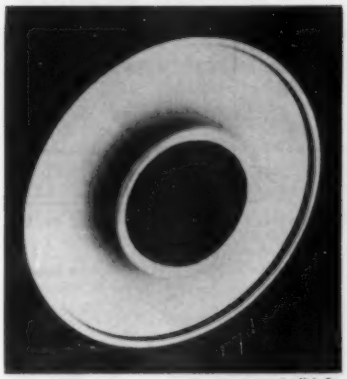
Melting Rate ↓ Condn →	Hot Rolled[a]	Hot Rolled, Annealed[b]	Cold Rolled, Annealed[c]
Slow			
Ten Str, 1000 psi	91	76	80
Yld Str, 1000 psi[d]	65	48	49
Elong, %[e]	14.25	24	17.5
Medium			
Ten Str, 1000 psi	86	73	74
Yld Str, 1000 psi[d]	71	47	43
Elong, %[e]	14.75	31.25	28
Fast			
Ten Str, 1000 psi	92	74	74
Yld Str, 1000 psi[d]	78	44	40
Elong, %[e]	16.25	26	27
Electrorefined[f]			
Ten Str, 1000 psi	66.5	—	—
Yld Str, 1000 psi[d]	35.3	—	—
Elong, %[e]	35	—	—

[a]At 1500 F; 0.08-in. sheet. [b]Ann. 1470 F for 1 hr, vacuum cooled, 0.08 in. sheet.
[c]Ann. 1470 F for 1 hr, 0.04 in. sheet. [d]0.2% offset. [e]In 2 in. [f]Annealed.
Source: WADD TR60-404 (Reactive Metals, Inc.).

TABLE 6—EFFECT OF TEMPERATURE ON MECHANICAL PROPERTIES OF ELECTRON BEAM MELTED VANADIUM[a]

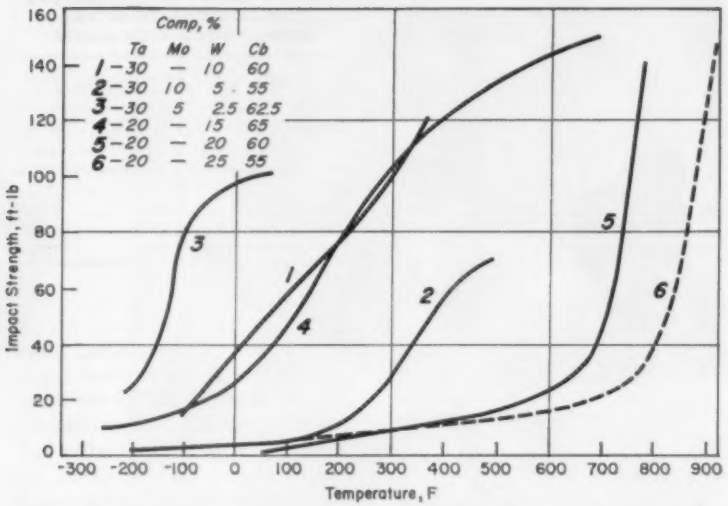
Test Temp, F	Melting Rate	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 2 in.), %
75	Slow	55	50	13.75
	Medium	71	59	14.25
	Fast	54	48	23.25
32	Slow	63	—	22
	Medium	66	—	24
	Fast	63	—	23
−40	Slow	68	—	21
	Medium	81	—	20
	Fast	69	—	27
−100	Slow	76	—	23
	Medium	84	—	20.75
	Fast	79	—	24
−40	Arc melt	72	—	11.5
−100	Arc melt	83	—	23.5

[a]Heat treatment: 1500 F, 1 hr; 1800 F, 1 hr; all in vacuum.
Source: WADD TR60-404 (Reactive Metals, Inc.).



Ladish Co.

4—Rocket exhaust entrance nozzle, 8 in. in dia, was forged from 3.5-in. dia ingot of electron beam melted tungsten. Nozzle weighs 16 lb.



5—Impact properties (keyhole notch test) of six columbium-base alloys produced by electron beam melting. (Stauffer Metals Co.)

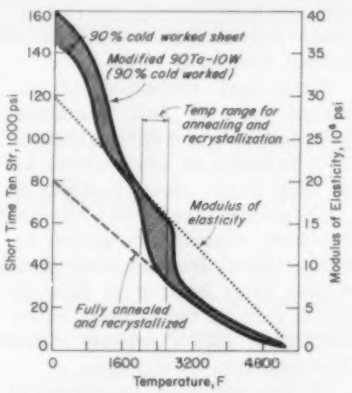
loys. In general, the elongations noted for the as-forged alloys are equal to or superior to those stated for commercial grades, and impact strengths are much higher. Some of these commercial grades are included in Table 7 for comparison.

Impact data for arc melted columbium alloys are included in Table 7 along with data for electron beam melted alloys. Fig 5 illustrates the effect of temperature on the impact strength of six electron beam melted columbium alloys.

6. Tantalum

Experiments at Stauffer Metals Co. indicate that, while tungsten can be alloyed with tantalum in the electron beam furnace, high tungsten contents present fabrication problems. Reducing tungsten content from 20% to 15% results in a marginally useful alloy, and reducing tungsten content still further to 10% results in a completely fabricable alloy with reproducible properties.

Mechanical properties — Fig 6 shows the effect of temperature on the short time tensile strength and modulus of elasticity of the 90% tantalum-10% tungsten alloy. Recrystallization occurs at approximately 2400 F, and the strength curves for both 90% cold reduced


90% cold worked sheet
Modified 90Ta-10W (90% cold worked)
Temp range for annealing and recrystallization
Modulus of elasticity
Fully annealed and recrystallized
Short Time Ten Str, 1000 psi
Modulus of Elasticity, 10⁶ psi
Temperature, F

6—Mechanical properties vs temperature of 90 Ta–10W alloy. (Stauffer Metals Co.)

TABLE 7—MECHANICAL PROPERTIES OF ELECTRON BEAM MELTED COLUMBIUM ALLOYS

Alloy Type[c]	Composition, %				As Forged[a]					Annealed[b]			
	Cb	Ta	Mo	W	Impact Str, ft-lb	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Red. Area, %	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Red. Area, %
SCb 199	67	30	3	—	—	67	42	18	84	58.2	51.8	38	78
SCb 204	65	30	—	5	—	73.7	41	18	79	61.9	56.4	25	71
SCb 205	68.5	30	—	1.5	231[f]	65.2	39.1	17	86	49.2	38.8	33	79
SCb 206	67.75	30	1.5	0.75	267[f]	79.5	41.5	16	57	45.5	36.2	47	80
SCb 207	62.5	30	5	2.5	37[f]	90.6	39.7	18	59	85.2	77.5	23	67
SCb 221	55	30	10	5	2[f]	87.9	32.6	33	75	59.3	—	—	—
SCb 222	60	30	—	10	52[g]	125.6	43.3	16	36	78.9	72.3	35.5	66
SCb 223	82	10	3	3	171[f]	65.9	—	38	70	65.9	57.1	38	70
D31[d]	—	—	—	—	7[h]	106	94	26	—	—	—	—	—
F50[e]	—	—	—	—	—	123	—	24	—	—	—	—	—

[a]Forged at 2000 F.
[b]1 hr, 2000 F.
[c]Stauffer Metals Co. designation.
[d]Arc melted Du Pont alloy: 80 Cb, 10 Mo, 10% Ti.
Source: Stauffer Metals Co., DMIC Rpt. 125.
[e]Arc melted General Electric alloy: 74 Cb, 15 W, 5 Mo, 1 Zr, 5 Ti, 0.05 O, 0.05% C.
[f]Charpy V.
[g]Keyhole.
[h]Type not stated.

Reactive Metals, Inc.

7—Ductility of electron beam melted cobalt is evident in rolled strip at right. At left is arc melted cobalt after rolling.

and recrystallized sheet merge. Although all specimens failed outside the gage length, preventing accurate measurement of elongation, the estimated elongation ranged from 6 to 10%.

Mechanical properties of as-forged bars of 90% tantalum-10% tungsten and 85% tantalum-15% tungsten at temperatures up to 5300 F are shown in Table 8.

Forgings, sheets—90% tantalum-10% tungsten is forged by conventional drop hammer techniques after heating to 2200 F. Usual forging temperature range is 2000 to 2200 F because of the high strength of the alloy.

To produce sheet, the ingots of 90-10 are forged into suitable slabs and ground or machined to remove the oxide skin. After vacuum annealing at 2600 F for 1 hr and cooling, rolling begins by reheating the cold slab to 500 F. In general one reannealing operation permits rolling a plate from 0.5-in. thickness down to 0.060-in. thickness. Maximum fabricability is obtained by vacuum annealing the rolled sheet at 2400 F for 1 hr.

7. Cobalt

Results pertaining to cobalt can be briefly stated. Three ingots were electron beam melted at slow, medium and fast rates and one ingot was prepared by arc melting. Of the four ingots only one —slowly electron beam melted— was fabricable after conditioning and forging to ½-in. plate at 1800 F. During hot rolling in air at 1800 F, the three other ingots cracked severely during the initial pass through the rolling mill. Fig 7 compares appearance after rolling of the arc melted cobalt and the ingot melted at a slow rate in the electron beam furnace.

TABLE 8—ELEVATED TEMPERATURE TENSILE STRENGTH OF TWO TANTALUM-TUNGSTEN ALLOYS[a]

85 Ta–15 W		90 Ta–10 W	
Temp, F	Ten Str, psi	Temp, F	Ten Str, psi
4880	4050	4850	3230
5060	3720	4865	3230
5060	3600	5030	2470
5300	2040	5300	1920

[a]As-forged bar stock.
Source: Stauffer Metals Co.

TABLE 9—MECHANICAL PROPERTIES OF ELECTRON BEAM MELTED COBALT[a]

Melting Method ↓	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (in 2 in.), %
Electron Beam	116.5	45.5	21
Arc[b]	34.4	30	0.4

[a]Melted at slow rate. Heat treated 24 hr, 1700 F, air cooled.
[b]As cast.
Source: WADD TR 60-404 (Reactive Metals, Inc.); Materials Selector Issue, M/DE, 1960-1961.

Mechanical properties presented in Table 9 cannot be directly related to the comparative data for as-melted cobalt because of the annealing treatment. It is sufficient to indicate the high ductility level of the electron beam melted cobalt.

How about uses?

Many of the applications for electron beam melted high temperature alloys are still classified. Most of these are in the rocket and missile field.

The alloy which is commercially available — 90% tantalum–10% tungsten—is readily forgeable in air, as shown in Fig 8. A rocket nozzle throat insert and retaining ring, forged from the 90 Ta-10 W alloy is shown in Fig 9. Electron beam melted molybdenum was forged into the 16-in. dia rocket nozzle keeper ring in Fig 10.

Stauffer Metals Co.

9—Throat insert and retaining ring for rocket nozzle are forged from electron beam melted 90 Ta–10W alloy. Strength is equivalent to that of pure tungsten up to 4500 F; oxidation resistance is superior to that of unalloyed tungsten.

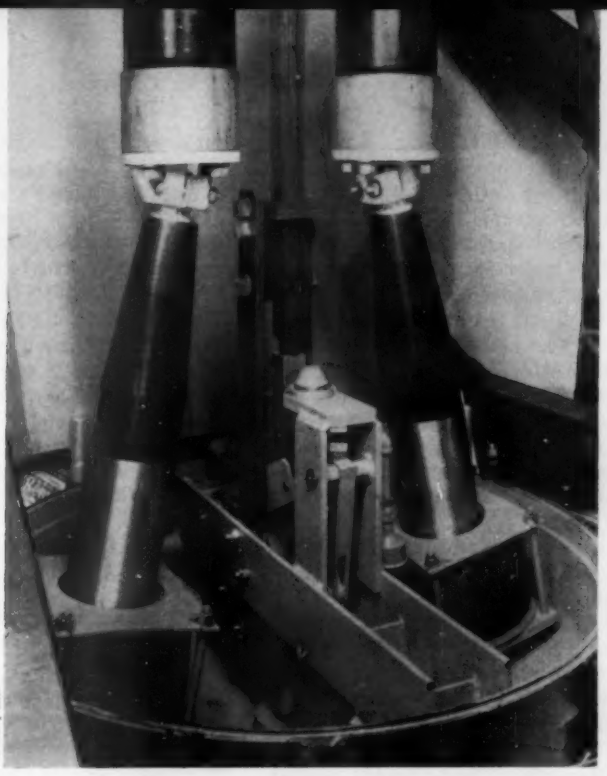
Stauffer Metals Co.

8—Ingot of 90% tantalum–10% tungsten is forged in air at 2000-2200 F.

Ladish Co.

10—Rocket nozzle keeper ring, 16 in. dia, 1.5 in. thick, weighing 28 lb, was forged from a 5.5-in. dia ingot of electron beam melted molybdenum.

Permali, Inc.



Permali, Inc.

1 Compreg wood laminate *used for bracing members in switchgear (right) provides desired combination of high strength and dielectric properties. Compreg was also selected for interrupting device (above) in outdoor oil circuit breaker, in this case because of its good arc quenching properties.*

New Developments in

Electrical Insulation Materials

Tougher environments are forcing industry to develop many new and improved insulation materials. Here are seven significant developments as reported at the most recent National Conference on the Application of Electrical Insulation.

How to overcome urethane encapsulation problems

Because of their light weight and good electrical properties, urethane foams are becoming increasingly popular for encapsulating electronic equipment. Some production problems have been encountered, but R. F. Newkirk of Nopco Chemical Co. believes these problems can be eliminated at little expense by using common sense.

For example, urethanes have an undesirable tendency to rise rapidly in the center of an electronic package and to form air pockets in corners. This problem can be licked by dispensing the urethane from the bottom of the package so that it gradually flows upward, thus forcing the air out and eliminating any tendency for pockets to form.

In cases where the package is so crowded as to prevent good foam distribution, a centrifuge can be used to throw the foam to the outer walls. This allows foaming to proceed from the extremities to the center, then up and out the hole where the foam was first deposited.

Pressures generated during foaming can be eliminated by providing excess holes or using retaining fixtures. If left open, the hole in which the foam was dispensed can serve as an excellent excess pressure vent. Also, temporary restraining fixtures can be used to strengthen the package until foaming pressure drops. Pressure during foaming reaches a maximum about 10 to 15 min after the foam is dispensed and drops rapidly thereafter.

(For a comprehensive report on new developments in urethane and other foams, see pp 119-134.)

Compregs are proving valuable in switchgear

Although compreg laminates are similar to some other cellulose-base laminates, they differ in that compreg wood fibers are not broken up but are impregnated with synthetic resins in their original veneer state. As noted by E. T. Rogers of Permali, Inc., their

greatest advantage lies in the fact that the impregnated wood veneers can be oriented in different directions to provide excellent mechanical properties (see Table 1). This important advantage of compregs has not been too well understood and there is a general tendency to associate compregs with decorative uses. When properly made, however, such laminates are a valuable engineering material.

The electrical properties of compregs show no significant variation with wood grain direction (Table 2). No significant changes in electrical properties occur below 176 F, and electrical properties are satisfactory up to 220 F under normal mechanical stresses. In general, higher temperatures will cause a drop in dielectric strength and an increase in power factor.

Compregs have excellent aging properties; tests over several years show that their electrical properties will not change significantly over normal operating conditions. Malfunctions or degradation of compreg switchgear parts are rare when the parts have been properly designed and processed.

The good combination of electrical and mechanical properties of compregs is proving valuable in switchgear that must function reliably and rapidly after long periods of inactivity. In such cases compreg dielectric components are electrically sound, prevent arc-over, and provide a low loss factor. They can also withstand high mechanical shock loads and, in the case of moving parts, are light enough to minimize acceleration forces.

Typical switchgear applications where compregs are being successfully used are:

- Lift rods for breaker blade and rod assemblies.
- Bracing members (see Fig 1) for oil circuit breakers. In this application the compreg bracings contain the lateral movement of moving parts and resist high bending stresses.
- Arc quenchers where, in addition to demonstrating slow and clean arc erosion, the compreg provides high mechanical strength.

New epoxy resin tapes for 155 C (Class F) use

Insulating tapes based on 60% glass filament and 40% epoxy resin are demonstrating their ability to provide exceptionally high strength and good dielectric properties. Previously, these tapes (Scotchply) have been used in 130 C (Class B) and 155 C (Class F) synchronous motor rotor coils for over three years with outstanding success. And, as reported by R. R. Charbonneau and P. L. Hedrick of Minnesota Mining & Mfg. Co., a new highly heat-stable epoxy resin system is now available for 180 C (Class H) units. Accelerated aging tests with the new resin system show no appreciable deterioration after 1000 hr at 446 F.

The epoxy tapes can be applied to coils in much the same way as other insulations. They can be cured and bonded in the slot and exhibit negligible shrinkage. Curing temperatures vary from 300 to 390 F. Although some resin may flow during curing, coil centering is maintained. Actually, the resin flow provides a thorough seal between the wrapper layers and makes the coil impervious to contaminants and reducing maintenance.

A considerable amount of data has been developed on the new materials; typical electrical and physical properties are shown in Table 3. Space does not permit details on their excellent mechanical properties which, in the case of tensile and compressive strength, are claimed to be higher than those of some structural metals.

Epoxy impregnant is usable to 450 F

Encapsulation and impregnation systems for airborne instruments are currently being subjected to tough environments such as severe thermal cycling, aging, salt spray, fungus and vibration. In looking for the ideal material to meet these conditions, J. A. Warburton and R. S. Norman of General Electric Co. report that one epoxy formulation appears to have significantly better overall properties than other materials. This formulation—epoxy novolac with a eutectic mixture of nadic anhydride and hexahydrophthalic anhydride—is especially notable for its high temperature properties and has been used in aircraft instrument coils having such rigorous specifications as: 400-hr exposure at 450 F, 24-hr immersion in diester oils at 400 F (see Fig 2), and 10 cycles from −85 F to room temperature.

Because of its excellent properties the mixed anhydride system (with and without filler) is expected to be useful for many high temperature airborne applications. Among its important advantages are its light weight and low shrinkage up to 450 F, and the

TABLE 1—MECHANICAL PROPERTIES OF COMPREGS

Direction →	Straight Grain	Cross Grain
Mod of Elast, 10^6 psi	2.5	2
Ten Str, psi	30,000	15,000
Compr Str, psi	17,000	40,000
Flex Str, psi	32,500	18,000
Izod Impact Str, ft lb/in. notch[a]	5.4	3.4

[a]Perpendicular to face, lengthwise.

TABLE 2—PHYSICAL AND ELECTRICAL PROPERTIES OF COMPREGS

PHYSICAL PROPERTIES	
Specific Gravity	1.3
Water Absorption (24 hr), %	
½ In.	1
1 In.	0.75
Max Operating Temperature, F	
Continuous	221
Intermittent	302
Rockwell H Hardness	90–100
Specific Heat, Btu/lb/°F	0.4
Coef of Ther Exp (straight grain), per °F	
Lengthwise	4.4×10^6
Crosswise	38.3×10^6
ELECTRICAL PROPERTIES	
Dielectric Strength, vpm[a]	
Perp to Laminations	
⅛ In.	360
¼ In.	250
½ In.	175
Par. to Laminations	87
Power Factor, %	
60 Cps	1.9
10^3 Cps	.3
10^6 Cps	.5
Dielectric Constant (60 cps)	4.5
Specific Resistance, ohm/cu cm	2×10^{12}

[a]Step-by-step at 77 F.

TABLE 3—TYPICAL PROPERTIES OF EPOXY RESIN TAPES[a]

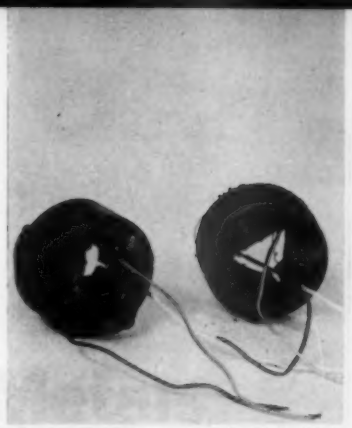
PHYSICAL AND MECHANICAL PROPERTIES	
Specific Gravity	1.84
Rockwell M Hardness	104
Water Absorption (24 hr), %	0.05
Wet Str Retention (2 hr boil), %	86
Heat Distortion (ASTM D648-45T), F[b]	346[c]
Flammability (ASTM D635-44)	Self-ext
ELECTRICAL PROPERTIES	
Dielectric Strength (ASTM D635-44)[d]	750
Insulation Res, Megohms	
50% RH, 73 F	5.3×10^9
50% RH, 140 F	2.7×10^9
90% RH, 73 F	3.3×10^9
90% RH, 140 F	9.7×10^9
Volume Res, ohm-cm	
50% RH, 73 F	4.9×10^{15}
90% RH, 73 F	4.9×10^{15}
Dissipation Factor,	
50% RH, 73 F	
60 Cps	0.0052
30 Mc	0.028
90% RH, 73 F	
60 Cps	0.036
30 Mc	0.033
Dielectric Constant	
50% RH, 73 F	
60 Cps	5.9
30 Mc	5.5
90% RH, 73 F	
60 Cps	7.0
30 Mc	5.5

[a]Tested on ⅛-in. thick laminate unless otherwise noted.
[b]At fiber stress of 264 psi.
[c]Limit of test equipment.
[d]50%RH, 73 F, 1/16-in. thickness.

fact that its plastic deformation temperature remains above 480 F after aging 500 hr at 450 F. The system can be used to impregnate coil windings (including Teflon-coated wire) for high temperature use. Furthermore, compared to silicone varnish, it appears to have equal resistance to heat aging and vibration, and better resistance to thermal cycling and diester oils.

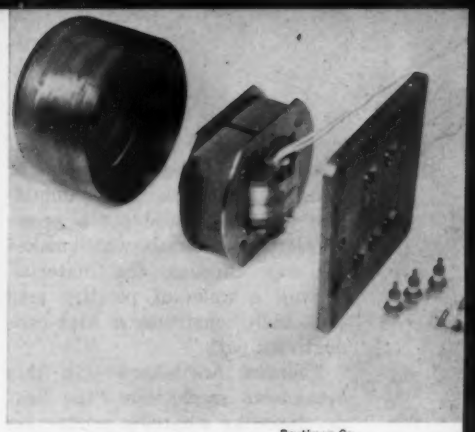
Inorganic insulation permits transformer use at 1100 F

As is well known, the problem of designing equipment to operate at high temperatures (on the order of 900 F) has created some critical insulation problems. In discussing these problems, F. B. Colby and K. G. Lagerlof of Raytheon Co. note that at high temperatures it is possible for conductor resistance to increase threefold and the electrical resistance of normally good insulators to be reduced by several magnitudes. Also, many common insulation materials such as paper, cloth, varnish, oil, rubber and plastics decompose rapidly and cannot be used.



General Electric Co.

2 Two aircraft coils *after immersion in diester fluid for 24 hr at 400 F. Epoxy novolac-impregnated stator (left) is unaffected. Coil impregnated with silicone varnish (right) was badly attacked: coil bundles became soft, film peeled.*

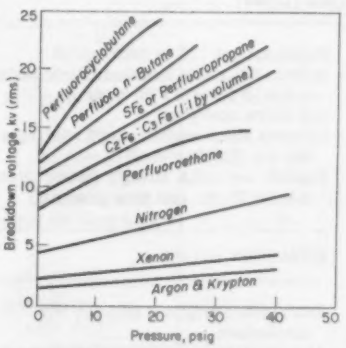


Raytheon Co.

3 Power transformer *made largely of inorganic materials can operate continuously at 1100 F. The case is filled with a ceramic potting compound to support the core structure.*

In order to overcome these problems equipment designers have had to turn to inorganic materials such as ceramic, mica, asbestos and certain glasses. A good example of how inorganic materials are currently being used is illustrated by the power transformer in Fig 3 which can operate as high as 1100 F. The transformer uses a layer insulation of phlogopite mica paper bonded with 15% silicone resin. The smaller wires are made of silver with a double glass serving; silver plated, oxygen-free, high conductivity copper wire is used for the larger sizes. After a degassing cycle the core and coil are impregnated with a colloidal silica to bond the two components together.

After impregnation the core and coil assembly is placed in the case where it is supported with a ceramic potting compound. The header is assembled to the case after the potting compound has dried. Then the entire assembly is heated at 1180 F under a vacuum, nitrogen is introduced under pressure, and the case is sealed.



4 Breakdown strength *of gases that might be used to protect components against oxidation at high temperatures. (Tests were conducted at 60 cps and 82 F, using ¼-in. nickel rod electrodes spaced 0.05 in. apart.)*

How dielectric breakdown relates to basic structure

One of the highlights of this year's conference was the special session on the importance of molecular structure in determining the properties of electrical materials. Of particular interest to application engineers is the explanation by C. R. Vail of Duke University on the relationship of molecular structure to dielectric breakdown.

Dielectric breakdown in a solid insulator starts by an action of electrons or ions and finishes in the formation of a highly conductive path through the dielectric. This breakdown can occur in a variety of ways, depending on the composition and molecular structure of the dielectric.

Intrinsic electric breakdown by impact ionization—In this breakdown mechanism free electrons "are accelerated by the applied field to velocities sufficient to ionize atoms with which they may collide. The electrons thus re-

leased then join with the original electrons in being accelerated to ionizing velocities. This cumulative ionization produces a growing electron avalanche which makes its way through the material, leaving a wake of positive ions that then constitute a high-conductivity path."

Thermal breakdown — In this breakdown mechanism "the heat developed by whatever conduction current there may be does not flow as rapidly as it is formed." Thus, the temperature of a region may get so high that melting or chemical decomposition occurs. This can cause a sharp rise in conductivity.

Other breakdown mechanisms— A variation of the above thermal breakdown mechanism can be caused by gaseous discharge in the internal voids of the dielectric or along its surface. Also, a dielectric may be shattered due to a "build-up in mechanical strain resulting from the formation, in a deionization process, of atoms that are too big for the structure."

Inert gases protect insulation at high temperatures

In evaluating the effects of high temperatures, I. F. Kilhan of Raytheon Co. notes that many advantages can be obtained by sealing high temperature electronic components in an inert gas to prevent decomposition. As shown in Fig 4, several gases have adequate dielectric properties. Although the gases with good dielectric properties are stable to 570 F, unfortunately they become unstable at 1100 F. Perfluoroethane appears to have adequate thermal stability at 570 F; however, at 1100 F it may be necessary to use nitrogen to obtain the required dielectric properties.

Protective gases are usually used at high pressures—two to three atmospheres at room temperature. Naturally, they can only be effective if their pressure is maintained. This means that all containers must be thoroughly leak tested and that protective devices such as pressure or density switches must be used on larger components.

Aerospace

New alloys are being used and still others developed to supply the light, strong, heat resistant fasteners essential for modern aircraft, rockets and missiles.

TABLE 1—QUALITATIVE COMPARISON OF AEROSPACE FASTENER METALS

Advantages	Limitations
TITANIUM	
Lightweight (0.168 lb/cu in. vs 0.290-lb/cu in. for steel)	Up to 30 times the price of steel
Directly interchangeable with most steel types	Low elastic modulus (16.5 x 10^6 psi vs 29 x 10^6 for steel)
No plating or protective coatings needed	Maximum service temperature about 1000 F
Excellent static strength and fatigue properties	Very poor correlation between hardness and tensile strength
Retains relatively good properties from –65 F to over 900 F	Screw threads often gall with mating threads of other materials
ZIRCONIUM	
Less dense than steel (0.236 lb/cu in., vs 0.290 lb/cu in. for steel)	Low tensile strength compared to titanium alloys or steel (80,000-100,000 psi vs over 180,000 psi for steel and titanium)
Resists chemicals which attack both steel and titanium	Much more expensive than titanium fasteners
Low neutron absorption cross section	Low maximum service temperature compared to superalloys or refractories
No platings or protective coatings needed	Poor correlation between hardness and tensile strength
Relatively good strength over a wide temperature range (–65 F to 1200 F)	
BERYLLIUM	
Weighs less than 25% as much as steel	Very expensive: unclad stock costs several times as much as platinum
Stiffness 25% greater than steel. (Elastic modulus is 40 x 10^6 psi vs 29 x 10^6 for steel)	Production can be an extreme health hazard; safety measures make fastener fabrication very expensive
Low neutron absorption	Reported to emit toxic oxides at temperatures above 1600 F
Extremely high strength-to-weight ratio (equal to that of a 450,000 psi steel)	Very brittle: threads must either be cut or hot rolled
Excellent mechanical strength (tensile strength over 100,000 psi; good shear properties)	
REFRACTORY METALS	
Retain useful strengths at extremely high temperatures	Must be coated against oxidation; coatings present serious problems and are expensive
Adequate protective coatings available for temperatures up to 3000 F	Relatively expensive
Useful at higher temperatures than other metals, 3000 F and above	Relatively dense
	Insufficient design data
	Recrystallization degrades properties

• *Now Research Engineer, Sciaky Bros., Inc., Los Angeles, Calif.*

Fasteners Use New Metals

by ***J. L. Chinn,*** *Norair Div., Northrop Corp.**

■ Aerospaee fasteners are the bolts, nuts, screws, rivets and washers used to hold modern aircraft and missile components together. There is an enormous variety of both standard and proprietary fasteners available.

The simplest method of classifying aerospace fasteners is to distinguish between those designed primarily to carry tension loads and those designed for shear loads.

Tension fasteners are usually heavier and more sturdy than their shear counterparts and often have specified fatigue requirements. They are used relatively infrequently in airframes but most jet engine bolts are this type and hundreds, in both standard and special sizes, may be used in a single gas turbine engine.

Many different kinds of shear fasteners are used in airframe construction. They range from rivets, drive pins, explosive rivets, "Lockbolts," blind fasteners, and quick-release asssemblies to light and featherweight nuts.

New fastener metals

The evolution of high performance, gas-turbine-powered aircraft depended on the development of high temperature steels and nickel or cobalt-base superalloys for jet engines and hot airframe components. Such new materials as A-286, Inconel X, Renè 41 and precipitation hardenable steels have now become indispensable structural materials.

The corresponding new, high strength faster materials include the reactive metals (titanium, zirconium and beryllium) and the refractory metals (molybdenum, columbium, tantalum, tungsten, chromium, and rhenium —a rare and expensive alloying element). They generally replace stainless steel in fasteners throughout airframes, power plants and missiles where their properties are needed and their relatively high cost is justified.

Fastener materials, other than conventional aluminum and steel alloys, vary considerably and there are no pertinent relationships among various classes of materials. The advantages and limitations of each class of material are given in Table 1.

Reactive metal fasteners

Titanium most popular

Titanium alloy fasteners exhibit excellent static and dynamic properties at temperatures up to about 1000 F and are readily available in both standard and proprietary configurations. They are unaffected by many corrosive environments and weigh about one-third less than their steel

TABLE 2—TITANIUM ALLOYS USED IN FASTENERS

Alloy ↓	Composition	Remarks
A-70 (all-alpha)	Commercially pure	Recommended for applications where strength is not significant
A-110AT (all-alpha)	5% Al, 2.5% Sn	Moderate strength and good elevated temperature properties
C-120 AM (alpha-beta)	4% Al, 4% Mn	Low response to heat treatment. The first large production fastener runs were made from this alloy
MST-6Al-4V (alpha-beta)	6% Al, 4% V	Sensitive to heat treatment. A very popular alloy from which millions of fasteners have been made
C-135 A Mo (alpha-beta)	7% Al, 4% Mo	Sensitive to heat treatment. A newer alloy from which very high strength fasteners are being made
B-120VCA (all-beta)	3% Al, 13% V, 11% Cr	Ductile in the as-received condition, easily formed, hardened by elevated temperature aging. No quench required

counterparts. Consequently, they are often specified throughout an entire airframe; they are very popular where the fastener population is heavy.

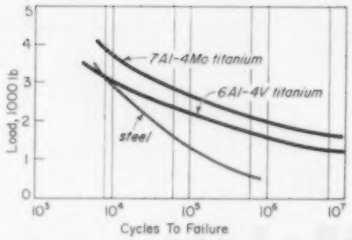
Commercially pure titanium, all-alpha alloys, alpha-plus-beta alloys and the all-beta alloy, have been made into aerospace fasteners. They are all mentioned in Table 2.

For the high strengths needed in aircraft and missile service, the commercially pure and all-alpha alloy titanium fasteners offer elevated temperature advantages. Lower temperature service and higher strengths may be expected from the heat treatable, alpha-beta titanium alloys.

Alpha-beta alloys—When the 6% aluminum–4% vanadium titanium alloy was commercially introduced, the producer's reports indicated that it would be a good fastener material. However, as it was more responsive to heat treatment than previously used titanium alloys, it had to be processed with greater care. Small differences in alloy additions from heat to heat had to be compensated for in adjusting the soak and aging temperatures to obtain desired strength levels. Once the processing problems were solved, the alloy made very good fasteners; average room temperature tensile strengths of 200,000 psi were achieved in the smaller diameters. The fasteners exhibit good fatigue properties, as well as proportionately good static strength, over temperatures ranging from −65 F to 1000 F.

The 7% aluminum–4% molybdenum titanium alloy fasteners are also sensitive to heat treatment and can be heat treated to high ultimate tensile strengths (237,000 psi). Ductility is increased at the expense of tensile and yield strengths by decreasing the soak temperature. Average single shear strengths over 115,000 psi are readily obtained.

Axial tension fatigue tests showed that 7% aluminum–4% molybdenum fasteners were far superior to identical fasteners in either alloy steel or 6% aluminum-4% vanadium titanium alloy. The 7% aluminum–4% molybdenum titanium alloy fasteners' fatigue strength does not change between room temperature and 500 F. Comparative room temperature S-N curves for alloy steel, 6% aluminum-4% vanadium, and 7% aluminum-4% molybdenum fasteners are presented in the accompanying graph.



***S-N curves** for two titanium alloys and a fastener steel.*

All-beta alloy—The 3% aluminum-13% vanadium-11% chromium alloy is a relatively new material. Although it is more ductile when annealed than the all-alpha or alpha-beta titanium alloys, cold head forming cannot be done. It is slightly heavier than all-alpha or alpha-beta alloys, and cannot withstand continued temperatures above 700 F. Fasteners have been made from this alloy and tested in several sizes and configurations.

Long aging times—from 40 to 80 hr—are recommended to obtain the high tensile strengths claimed for the titanium alloy. Extended aging adds appreciably to fastener production cost and cannot be justified because lighter weight fasteners made from other titanium alloys are available at equal or lower prices.

Titanium applications—Saving a pound by directly substituting titanium fasteners for their steel counterparts costs about $50 or more, depending upon size, type and quantity involved. Nevertheless, millions of titanium fasteners are being used each year by the aerospace industry. Very few titanium nuts have been made because of their high cost, difficult production requirements and tendency to gall with titanium fasteners.

Because of their interchangeability there is no essential difference in appearance between titanium alloy and steel fasteners. Most airframe producers refuse to divulge details on titanium fastener applications for proprietary reasons. It is known that many producers use them, but the exact extent is unknown.

One Northrop study showed that nearly 100 lb of weight per airplane could have been saved by directly substituting titanium for steel fasteners on the Northrop F-89. Substitution of titanium fasteners could reduce the weight of an eight-engined heavy jet bomber by more than 1200 lb. One certain, but expensive, way to cut the weight of an overweight airframe is direct substitution of titanium for steel fasteners.

Other reactive metals

Zirconium fasteners have been used in chemical and atomic energy equipment, including nuclear reactors, because of their low neutron absorption and corrosion resistance. They are more expensive and heavier than titanium and not as strong. Zirconium is less abundant than titanium and is more difficult to claim from its ore. Its special properties do, however, justify its limited use for specialized fasteners.

Beryllium fasteners, still in the developmental stage, would be first used where either their low density and high stiffness or their nuclear properties are demanded. A few have been machined from solid bar by Nuclear Metals, Inc. The first beryllium fasteners produced by conventional hot head forging methods have only been recently developed by a joint effort of Norair Div. of Northrop Corp., Brush Beryllium Co. and Voi-Shan Industries. Anticipated beryllium fastener uses include: nuclear reactor components, nuclear weapon components, high energy particle accelerators, inertial guidance system components, heat sinks, and aerospace structures and skins.

Most refractory metal fasteners experimental

Refractory alloy fastener development is so recent that such fasteners are just beginning to find production applications for extreme temperature resistance. Threaded molybdenum alloy fasteners and rivets have been developed to a much higher degree than other refractory fasteners for use in ramjet combustion chambers and similar locations requiring heat resistance up to 3000 F.

Emphasis to date has been on 0.5% titanium-molybdenum alloy for threaded fasteners. Commercially pure molybdenum is recommended for rivets which must be upset at installation. Zirconium, and 0.7 to 0.8%, and 0.5% titanium have been alloyed with molybdenum. Some of the resulting alloys have rather good ductility, increased mechanical properties and higher recrystallization temperatures. Although greater ductility is realized in electron beam or arc melted refractory alloys, sintered materials of the same composition have higher recrystallization temperatures.

Non-molybdenum refractory alloy fasteners will be developed as soon as availability of commercial alloys permits. It is known that refractory materials with more that 50% tungsten are difficult to make. However, tantalum and columbium alloys are made with relative ease and will probably become useful fastener materials. Columbium fasteners are already being evaluated for high temperature applications.

Recrystallization and oxidation problems

One of the goals for aerospace fasteners is the ability to withstand 3000 F service temperatures without recrystallization. Although recrystallization does not make fasteners useless, it does reduce ductility, enlarge grain size, and increase brittleness. Recrystallization of molybdenum alloys is said to be more harmful than recrystallization of columbium alloys.

A general disadvantage of refractory metals and alloys is their tendency to oxidize at temperatures far below those at which they retain useful strengths. Of all the refractory metals, molybdenum is the worst offender. Pure molybdenum is said to oxidize 100 times more rapidly than columbium. For this reason, all refractory materials, and especially molybdenum, destined for truly high temperature service must be completely encapsulated or enveloped in a protective coating. If an electroplated coating on molybdenum has a pinpoint-size imperfection, the molybdenum will oxidize very rapidly. Tests show that after a few minutes at 2000 F molybdenum will oxidize through a minute imperfection and leave only a "shell" of coating. Although columbium, tantalum, tungsten and their alloys oxidize more slowly, they too require protective coatings at about 1300 F and above.

Chromalloy W-2 and Durak MG are good examples of coatings which can protect refractory materials against oxidation at temperatures above 3000 F. Coating thickness determines the length of time at which refractory materials can withstand maximum temperatures before failure.

Even though rhenium additions increase the recrystallization temperatures of refractory materials, they do not increase oxidation resistance. Rhenium is also reported to compound the difficulties encountered in diffusion coating deposition.

Future potential is good

Future success of weapons and space vehicle systems depends largely on increasing speed and decreasing weight. To increase speed, more thrust is required, and to decrease weight, more effective use of existing materials (or new materials development) is required. Since fasteners are integral to flight vehicle materials systems, their importance cannot be overemphasized. In addition to increased heat resistance, fasteners should be able to withstand simultaneously a number of natural and induced hyper-environments.

We believe that future development could result in titanium alloy fasteners with useful strengths at 1200 F for protracted high temperature service. Zirconium fasteners will probably be limited to chemical and nuclear devices. The future of beryllium fasteners has hardly been penetrated. In addition to its desirable physical and mechanical attributes, today's beryllium has been reported to retain useful strength in the 1500 F range. The future of beryllium fasteners appears bright, but will depend largely upon improvements in ductility and strength and decline in price.

Refractory metal fasteners also appear to have an almost unlimited future. More ductile tungsten alloys are needed so that they can be economically converted into fasteners. Refractory alloys capable of operating in 4500 F service are already being sought.

Ideal refractory alloy fasteners must have protective coatings capable of operating at temperatures as high as those at which the base material is useful. Self-healing, toughness, and heat resistance are coating essentials. Cost will continue to be an important factor. Reliable methods for nondestructive testing of coatings, as well as processes for "in the field" repairs of damaged or imperfect coatings, must be developed.

Equipment and standardized methods for static and dynamic testing of fasteners at temperatures above 2200 F do not now exist. They must be developed.

The requirements for future fastener development closely resemble the requirements for most other elements of a materials system. Progress will probably be in direct proportion to our total aerospace effort.

Keeping Temperatures Down—II

Ablation, Heat Sink

The Materials That Make Them Work

In the first of these two articles on the problem of keeping temperatures down (M/DE, Feb '61, p 101) we took a broad look at the five basic methods of control. Let us now see in more detail how these techniques can be implemented by the three important materials systems.

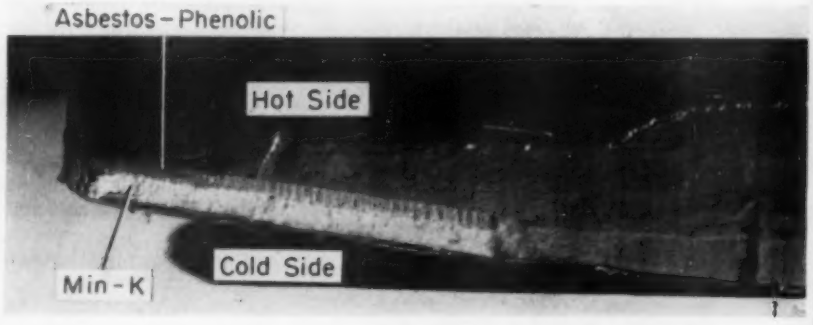
by John O. Collins and Dr. Sidney Speil, *Aviation & Special Insulations Section, Johns-Manville Research Center*

Combination Insulation Best for Missile Combustion Chamber

A good example of how insulation systems can be combined effectively is shown in this cross section of an insulating blanket for a missile combustion chamber. Service conditions dictated that the outer surface be kept below 300 F even though the hot side of the blanket reaches 1800 F.

As shown, a low density alumino-silicate filler is used where space permits a relatively thick material. This material was also selected in view of the time of operation — 300 sec — which is borderline between transient and steady-state heating.

The restricted area near the chamber exit (left) permitted only ¼ in. of insulation. Despite its high heat absorbing capacity, ¼ in. of asbestos-phenolic insulation would not restrict the cold surface temperature to 300 F.



Also, lightweight Min-K alone was insufficient to absorb the heat flux. Consequently the two materials were combined such that Min-K is used on the cool side and asbestos-phenolic on the hotter side. This configuration permits the asbestos-phenolic insulation to attain a higher temperature, thus attaining the maximum benefit from its high specific heat and density. In addition to providing the desired combination of thermal properties the composite insulation is lighter than an insulation system made completely from asbestos-phenolic.

Ablation systems and materials

The mechanism of ablation is very complex. Briefly, however, the heat of ablation of any material includes four main energy factors:

1. The heat energy absorbed by the material (before any physical changes occur), resulting in a temperature rise of the material.

2. The heat energy absorbed during physical changes such as vaporization, melting or sublimination, and during chemical changes such as depolymerization.

3. The heat energy absorbed and "blocked" by the transpiration cooling effect of gaseous products as they pass through the outer layers of the material, through the boundary layer, and into the atmosphere.

4. The heat energy dissipated by radiation.

The relative importance of each of these energy factors is a function of heat flux (Btu/sq ft/sec). For example, factors 1 and 2 usually predominate when heat flux is relatively low. As heat flux increases, however, factors 3 and 4 attain greater importance, although factors 1 and 2 do not necessarily become less significant.

The ablating material also determines which factor(s) will predominate. Hydrogen gas (H_2) has

and Radiation

a heat content (Btu per lb) almost three times greater than that of organic plastic $(CH_2)_n$, and 27 times greater than that of silica (SiO_2) at 8500 F *(Gruntfest and Shenker)*. Thus, the greater the hydrogen content, the more predominant energy factors 1 and 2 become. Likewise, hydrogen generates four times more volume of gas per gram than the organic plastic, and 20 times more than silica. Since the heat energy absorbed and "blocked" by the transpiration cooling effect of gaseous products is a direct function of the amount of gas generated, this energy factor becomes more important as hydrogen content of the ablation material increases.

These two physical properties of hydrogen—its heat content and its volume of gas per gram—explain why organic fiber-reinforced plastics are superior to asbestos or glass-reinforced plastics at very high rates of heat flux. They also partially explain the general rule obtained from test data that the higher the heat flux, the higher the resin content should be in the reinforced plastic.

Each ablation material has a minimum heat flux value below which ablation will not occur.

TABLE 1—APPROXIMATE MINIMUM HEAT FLUX NEEDED TO START ABLATION

Material	Heat Flux (q_{max}), Btu/sq ft/sec
Glass-Phenolic	100
Nylon-Phenolic	100
Pure Silica-Phenolic	1000
Graphite	2000[a]
Quartz	2000[a]
Teflon	100

[a]Sublimation.

Above this value, the greater the stagnation temperature (and consequently the heat flux) the greater will be the ablation rate or rate of energy dissipation. Since the amount of material is finite, the life of the system is limited by time.

The minimum heat flux required for starting ablation of some common materials is shown in Table 1. A summary of the more common ablation materials also appeared in "Reinforced Plastics at 3000 to 25,000 F," M/DE, June '58, p 100. Since publication of this article, new resins such as phenyl - silane, triallylcyanurate (TAC), and modified epoxies have been developed. However, these materials are still being evaluated and cannot yet be generally compared to the more common ablation materials.

Heat sink systems and materials

Heat sink thermal accommodation systems rely on a material's ability to store heat without changing its integrity. The usefulness of heat sink systems generally lies in the heat flux range of 0.1 to 10 Btu/sq ft/sec. And, as shown in Fig 1, next page, they are limited to short-time heat pulses.

Heat sinks may take either one or a combination of the following forms:

1. The structural shell itself, which is provided with greater than normal thickness.

2. An external layer composed of nonstructural materials with high heat capacity.

3. A liquid coolant adjacent to the internal surface of the structural shell.

Let us look at the first two systems in more detail (liquid coolant systems will not be examined here: see last month's article by Harry A. King).

TABLE 2—SPECIFIC HEATS OF POTENTIAL HEAT SINK MATERIALS

Material ↓	Spec Heat (Cp), Btu/lb/°F	Temp Range, F
METALS		
Beryllium	0.49-0.78	200-1800
Magnesium	0.25-0.31	200-1200
Aluminum	0.23-0.27	200-1000
Titanium	0.13-0.16	200-1200
Chromium	0.12-0.18	200-2000
Copper	0.09-0.12	200-1800
Molybdenum	0.06-0.07	200-2000
CERAMICS		
Beryllia	0.30-0.52	200-1800
Magnesia	0.25-0.29	400-1800
Alumina	0.22-0.3	200-2000
Quartz	0.18-0.29	200-2000
Zirconia	0.12-0.14	200-1600
REINFORCED PHENOLIC PLASTICS[a]		
Asbestos	0.31-0.36	100-500
Glass	0.25-0.29	100-500

[a]Calculated for 40% phenolic resin content.

Thick structural shells

In this thermal accommodation system the thickness of the shell becomes a function not only of the total heat input (Q) but also of the structural strength required at high temperature. Thus, as total heat input increases, the added thickness of the shell results in an extremely high weight penalty per square foot.

High heat capacity layers

The choice of an external layer of heat sink material is a function of the material's specific heat and its adaptability. Table 2 lists the specific heats of some of the more common metals, ceramics and reinforced plastics which are potentially useful as heat sink materials. The design of external layers of these materials is critical in that the respective weights of the shell and heat sink layer must be balanced so as to obtain the combination with the minimum overall weight and required strength.

In applications where thickness rather than weight of the system is most important, the product of

density and specific heat (ρC_p) is the controlling factor in selecting the sink material. Table 3 shows the density times specific heat factors for the same materials shown in Table 2. Note that with the exception of the plastics the order of preference of the materials has changed considerably.

Thermal diffusivity important at low heat fluxes

For those low heat flux applications where heat blockage may be critical, the primary material selection criterion is usually thermal diffusivity: thermal conductivity divided by the product of density and specific heat. Thermal diffusivity must be low to obtain high heat blockage in a heat sink. Therefore, the high conductivity of metals normally renders them undesirable, particularly where the maximum temperature of the inner surface of the sink must be kept low. As shown in Table 4, metals have high diffusivity values despite their ability to absorb relatively high values of total heat input.

It is obvious from Table 5 that ceramic materials such as zirconia, quartz and alumina have greater heat stopping characteristics than metals. Also, ceramic coatings over the basic shell structure provide a relatively large thermal gradient to the shell. Thus, they not only protect the shell but the internal components as well. In addition, the extremely high melting points of ceramics are an advantage because low diffusivity materials are characterized by high concentration of heat at their surface.

How plastics perform as heat sink materials

Plastics can be considered as true heat sink materials despite the fact that they volitilize to a certain extent when heated to over 500 F. (Such volatilization is not considered the same as ablation which, for most plastics, occurs above 3000 F.) The volatilization reaction is endothermic and is a time-temperature function. Thus, it is difficult to calculate accurately the thickness of plastic required for a given application.

TABLE 3—SPECIFIC HEAT-DENSITY FACTORS OF POTENTIAL HEAT SINK MATERIALS

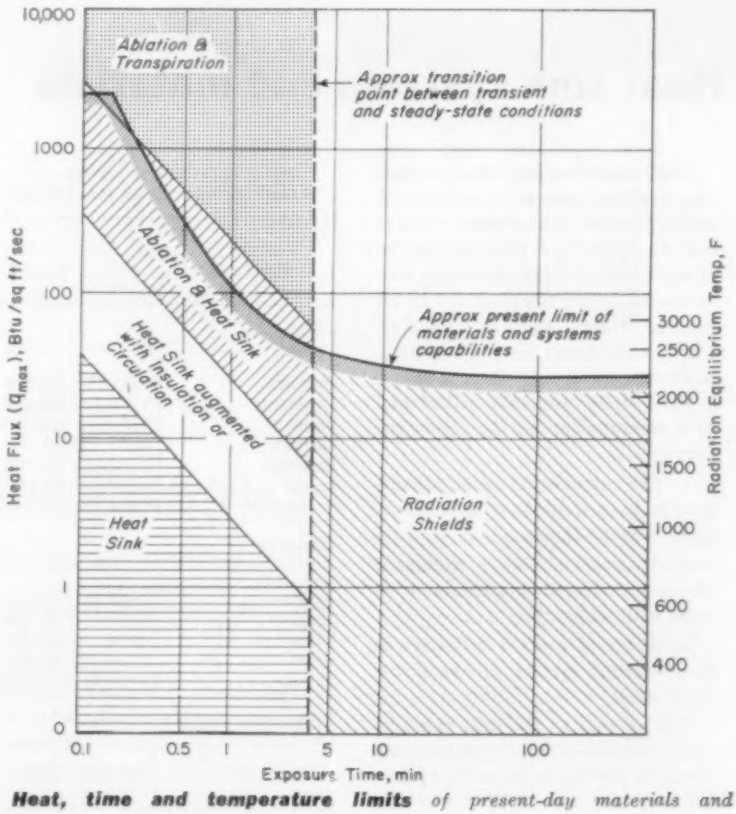
Material ↓	Spec Ht–Density Factor (ρC_p), Btu/cu ft/°F	Temp Range, F
METALS		
Beryllium	56-85	200-1800
Chromium	54-76	200-2000
Copper	50-63	200-1800
Aluminum	39-43	200-1000
Molybdenum	38-44	200-2000
Titanium	36-44	200-1200
Magnesium	27-32	200-1200
CERAMICS		
Alumina	55-73	200-2000
Magnesia	56-61	400-1800
Beryllia	52-89	200-1800
Zirconia	40-45	200-2000
Quartz	24-39	200-2000
REINFORCED PHENOLIC PLASTICS[a]		
Asbestos	33-38	100-500
Glass	27-31	100-500

[a]Calculated for 40% phenolic resin content.

TABLE 4—DIFFUSIVITY FACTORS OF POTENTIAL HEAT SINK MATERIALS

Material ↓	Diffusivity[a] ($K/C_p\rho$), sq ft/hr	Temp Range, F
METALS		
Titanium	0.3-0.2	200-1200
Beryllium	1.7-0.5	200-1800
Chromium	1.0-2.2	200-2000
Molybdenum	2.4-1.3	200-2000
Aluminum	3.2-2.4	200-1000
Magnesium	3.4	200
Copper	4.4-2.9	200-1800
CERAMICS		
Zirconia	0.03-0.02	200-2000
Quartz	0.04-0.1	200-2000
Alumina	0.3 -0.04	200-2000
Magnesia	0.3 -0.07	400-1800
Beryllia	2.5 -0.1	200-1800
REINFORCED PHENOLIC PLASTICS[b]		
Asbestos	0.005-0.008	100-500
Glass	0.006-0.01	100-500

[a]Diffusivity factor = thermal conductivity/(specific heat × density).
[b]Calculated for 40% phenolic resin content.



Heat, time and temperature limits *of present-day materials and configurations.*

It will be noted from Tables 2, 3 and 4 that all values for plastics are limited to the 100 to 500 F range. Above 500 F, physical properties such as thermal conductivity and specific heat can only be calculated from transient thermal tests. Even then the values are applicable only for the particular set of conditions under which they were obtained. However, despite the small amount of accurate data above 500 F, experience shows that reinforced plastics, because of their low diffusivity and high heat blockage characteristics, are satisfactory for many heat sink applications in the medium time and temperature range.

TABLE 5—PROPERTIES OF CERAMIC MATERIALS

Material ↓	Density (ρ), lb/cu ft	Ther Cond (K), Btu/hr/sq ft/°F/in.	Ther Cond × Density (Kρ), Btu/lb/hr/ft⁴/°F	Approx Temp Limit, F
SPRAYED COATINGS				
Alumina	200	19 (2000 F)	317	3000
Zirconia	325	8 (2000 F)	216	4200
BONDED OXIDES				
Alumina Bonded With Aluminum Phosphate	190	7 (2000 F)	114	3500
Zirconia Bonded With Zirconium Phosphate	242	6 (2000 F)	121	4000
INSULATING BRICK				
High Density	65	3.37 (1200 F)	219	3000
Low Density	33	1.18 (1200 F)	39	2000
FOAMS				
High Density	22	0.75 (800 F)	16.5	1600
Low Density	11	1.8 (800 F)	19.8	2000
Crystalline Glass	156	14 (70 F)	177	2250
Special Fiber-Reinforced Silicate*	20	0.43 (1200 F)	8.6	2000

*Min-K 2000.

Radiation systems and materials

Radiation systems and materials are used mainly for steady-state and long-term, quasi steady-state conditions. The thermal effectiveness of the radiation system is based on its ability to reach a sufficiently high surface equilib-

Transient vs Steady-State Heating

In order to better understand the requirements of insulation systems for aerospace applications let us take a brief look at aerodynamic heating and the materials and systems that can be used to dissipate its energy.

Transient, steady-state heating defined

Aerodynamic heating can be divided into two categories:

Transient heating is characterized by a bell-shaped curve of heat flux (q, in Btu per sq ft/sec) vs time (t, in sec). The total heat input (Q, in Btu per sq ft) is then represented by the area under the curve.

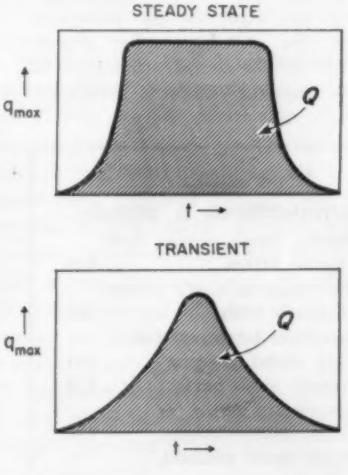
Steady-state heating is characterized by q_{max} being sustained during most of the flight time, not just for a short period. Again the area beneath the heat flux-time curve represents the total heat input.

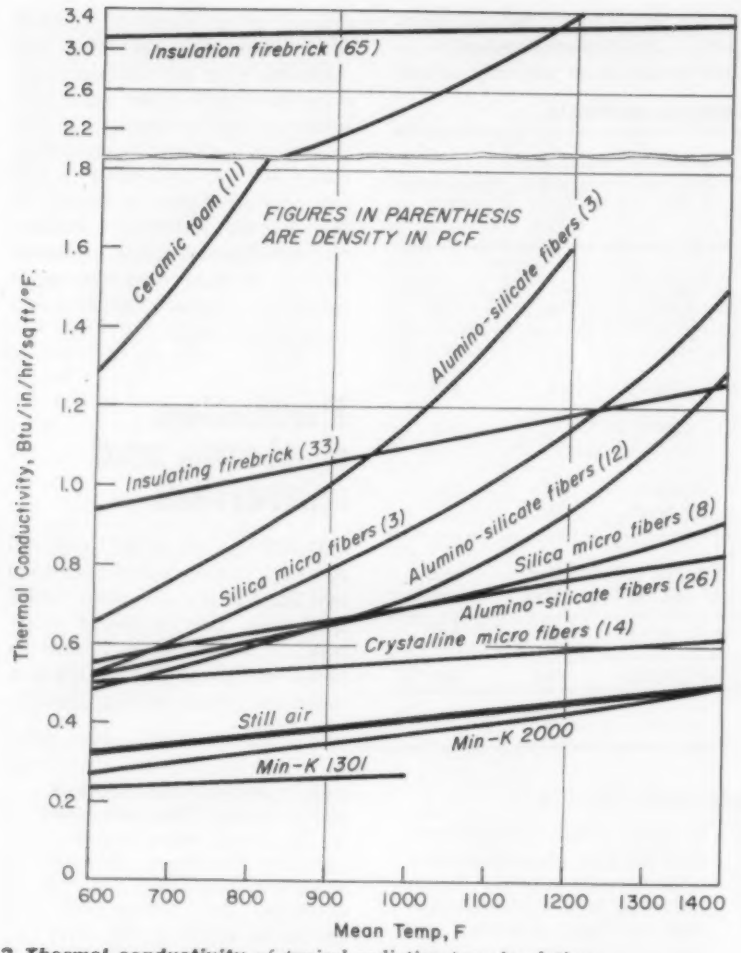
Theoretically, we should not use a constant value of time to separate transient and steady-state heating for all materials. The reason is that the unique thermal properties, density and thickness of each material determine the time when steady-state conditions are reached. Nevertheless, it is generally accepted that for most materials the transition between transient and steady-state heating occurs at about 5 min.

Thermal protection systems are two basic groups

Thermal protection systems can be divided into either absorption systems or radiation systems. An absorption system uses materials that can absorb heat and is effective for short-time applications. A radiation system uses materials that are capable of re-radiating heat and is most effective for long-time applications.

The mechanism of heat absorption can be accomplished by transpiration, ablation or heat sink. Each of these systems has a general area of usefulness which is determined by its heat flux and to a lesser degree by exposure time, as shown in Fig 1 (p 116). There really is not a sharp delineation between the areas shown, but some degree of overlap exists. The heat sink system is best suited for relatively low heat fluxes. Ablation is useful for high heat flux applications. And transpiration cooling is probably the most satisfactory system for very high heat fluxes. In addition, certain medium fluxes are most efficiently accommodated by a combination of systems.





2 Thermal conductivity *of typical radiation type insulations.*

rium temperature in order that it can re-radiate the heat back into its origin as fast as it is received. The maximum surface temperature, and hence the maximum heat flux, that can be handled is governed by the temperature limit of the material. Present limits for radiation systems lie between 2000 and 2500 F, or about 20 to 50 Btu/sq ft/sec heat flux.

Metal-clad insulations

Double-wall systems consisting of metal-clad fibrous or molded insulations have been the mainstay for jet engines for many years. Typical constructions consist of a felt or blanket made from alumino-silicate or silica fiber encased in a thin, heat resistant alloy envelope. Depending on the desired contour, they can be designed as flexible wrap-ons, or semi-rigid or rigid insulation blankets.

The most sophisticated type of metal-clad insulation is the barrel-like structural blanket which completely encases a jet engine. This advanced hollow-wall construction or insulating shroud combines stressed skins and structural members with an insulating shroud. It serves not only as an insulation but also as an air duct which must often withstand high positive and negative pressures, as well as structural flight loads.

Alumino-silicate is one of the most common insulation materials used in radiation metal-clad systems. Felts made from these fibers can withstand continuous service at 2000 F and are available in densities from as low as 3 to as high as 30 pcf (lb per cu ft). As Fig 2 shows, conductivity improves (i.e., it drops) markedly at high densities. However, note that the conductivity-density factor increases with temperature; it is this factor, rather than conductivity, that is usually the important selection criterion.

Silica micro fibers are also stable at temperatures up to 2000 F. The thermal conductivity of 3 and 8 pcf felts is shown in Fig 2.

Both of the above materials are available in many forms, including inorganic-bonded boards and sheets of varying rigidity, castable cements, extremely thin felts, papers, roving, ropes, braids, etc. The high density molded products can be machined or pressed to specific shapes.

Temperature limit of the materials depends partially on the intensity of mechanical abuse encountered. Severe vibration tends to reduce temperature limit, whereas under negligible mechanical abuse the materials can often be used to 2500 F or higher. Silica micro fibers are stable to 2000 F, but even though their vitreous structure is destroyed above this temperature they still retain their fibrous form and insulating value. This is particularly true when the fibers are bonded with inorganic binder.

New insulations

Because of the importance of the high temperature problem, development in recent years has been intensively directed toward reducing the thermal conductivity and weight of insulation materials. Two of the more promising mate-

(continued on p 149)

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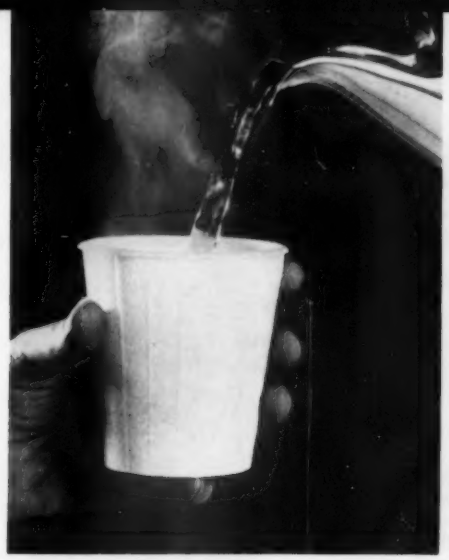
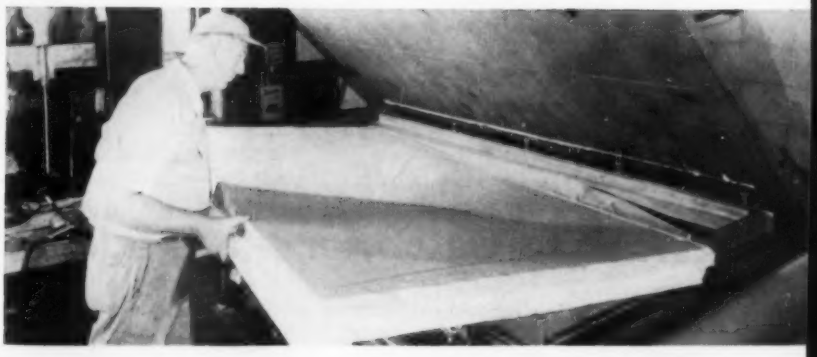




What's New in Foam Plastics

by M. W. Riley, *Associate Editor, Materials in Design Engineering*

Materials ▸

Processing ▸

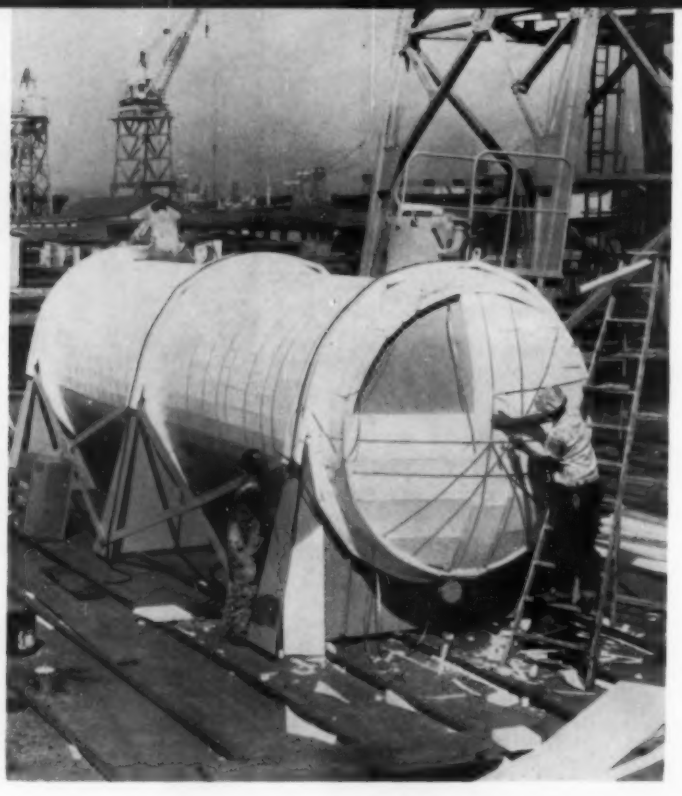
Applications ▸

The news in foam plastics is being made by flexible and rigid urethanes, polystyrenes, and to a lesser degree by epoxies, polyethylene, polypropylene and silicones. These are the plastics in which recent developments in engineering performance, processing, or applications are of special interest to engineers and designers.

Many important developments have occurred in the field of cellular plastics. Not all of them can be covered in the space permitted. The attempt here is to cover those developments of most significance since our earlier report in the June '56 issue. No effort has been made to balance the discussion among all types of foams.

Table 1 on p 122 summarizes all the foams currently available. A brief status report at the end of this article gives some additional information on those foams not discussed in detail in this article.

Since building and architectural materials are not within the editorial scope of M/DE, the large and growing volume use of foams in buildings is not covered here.



Koppers Co.

Polystyrene insulation 'wraps' *wine in these 10,000-gal tanks for above-deck shipment from California to New Jersey. The 2-in. thick boards, molded by Pelafoam, Inc. for United Vintners, Inc., keep the wine below a critical temperature of 80 F during the trip through the Panama Canal.*

What to watch for — at a glance . . .

Following is a capsule summary of some of the more promising developments. For the most part the items are based on unpublished information. Few additional data are available. Where more information is available it will be found in appropriate sections of the article.

. . . in materials

▸ New fluorocarbon-blown epoxy foam under development may give urethanes a run for their money in low temperature insulation.

▸ Cellular polypropylene, under development study, may provide unsurpassed performance for certain types of wire and cable insulation.

▸ Improvements in cellular polyethylene may put this slow starter into a number of uses other than electrical, e.g., those requiring toughness and energy absorption.

▸ New approaches to combining expandable polystyrene beads and other resin systems could provide some startling results in performance as thermal insulation.

▸ Space-triggered urethane foams appear to be in the offing. They would offer a highly efficient means of putting a large, low mass structure in space. Ingredients could be sent aloft in plastic film; triggering mechanism could be solar radiation.

▸ New hydrophilic urethane foams are about to become commercial. Earlier hydrophilic foams are reported to have met limited success.

▸ New styrene-acrylonitrile copolymer foam, aimed at flotation use, has excellent resistance to gasoline and oil.

. . . in processing

▸ Frothing, a method of partially pre-expanding urethanes, could substantially reduce tooling and production costs of foam-in-place thermal insulation for appliances. System also provides greater stability of foams during expansion.

▸ One-shot molding or foaming-in-place of flexible urethanes, in limited use now, may be the next big step toward more efficient design with urethanes.

▸ Blow molding and other forming techniques may produce radical changes in design possibilities of cellular polystyrene. New extruded cellular polystyrene can be blow molded, though work is still developmental.

▸ Spraying urethane foam insulation is becoming more widely accepted commercially; some of the more pressing problems are reported to be well on the way to solution.

. . . in applications

▸ The battle of the refrigerators has not been won yet, though urethanes are the hottest prospect. Fluorocarbon-blown urethanes will be replacing glass fiber in more compressor-type home refrigerators in '61. Several refrigerator manufacturers are now tooling up; approach has been cautious because of cost and lack of experience.

▸ Substantial increase in the use of foam insulation in refrigerated transportation and storage facilities may result from proposed legislation by states reducing maximum permissable temperature for transporting and storing frozen foods.

▸ Auto seating design and cost may soon reflect the newer concept of designing for maximum use of urethane foams, e.g., possibly slush-molded vinyl seat with flexible urethane foamed in place against trim and around springs.

▸ "All-foam" furniture will consist of structural framework around which is foamed-in-place flexible urethane foam cushioning.

▸ The 600 F service rigid urethane recently announced may enter some substantial volume applications, e.g., weldable panels.

▸ Flexible urethanes for bedding and clothing interliners appear on the verge of large commercial volume. Primary benefits in bedding: light weight, long life, stain resistance. In clothing: lightweight thermal insulation.

Polyurethane foams

Although all early urethane foams, both flexible and rigid, were produced by reacting either polyester resins or castor oil with isocyanates and water, most present foams are made with polyethers rather than polyesters. Polyether foams are lower in cost, and flexible types provide better compression-deflection characteristics for comfort seating.

Polyesters are still being used in certain types of foams. In rigid foams they are used where maximum heat resistance is demanded, or for certain types of specialty foams, e.g., foam filters. In flexible foams, polyesters are being used for clothing interliners. Flame bonding, the newest and most promising technique for bonding the foam to the fabric, can only be accomplished with polyester-type foams at present.

Rigid urethanes

The biggest development in rigid urethanes in the past few years has been the commercial realization of polyether-type foam blown with a fluorocarbon gas (trichlorofluoromethane, e.g., Freon 11, Genetron 11, Isotron 11, or Ucon 11). Cells of the resulting foam are filled with the fluorocarbon which has a much lower thermal conductivity than the carbon dioxide which fills other types of urethane cells. Fluorocarbon-blown foams have k factors on the order of 0.11 to 0.17 Btu/hr/sq ft/°F/in.

In addition to having a lower k factor, such foams are lower in cost. The fluorocarbon replaces some of the more expensive isocyanate in the formulation. Lower cost has been the main reason for the use of such foams in non-insulation applications, e.g., certain bouyancy units for recoverable drones.

Table 2 shows typical properties of rigid urethane foams in three density ranges. The three shown have been selected as representing common densities used for various applications.

The lowest range shown, 2.0-2.5 lb per cu ft, is that used for low temperature insulation; the 4-7 lb per cu ft range is used for structural or load-bearing applications; the 18-25 lb per cu ft range is used for extremely high load-bearing qualities. Fig 1 shows general performance characteristics of fluorocarbon-blown polyether foam systems.

Cost—Costs of foam materials are difficult to state meaningfully in general terms. (A nomograph for determining cost of foam parts can be found on p 137.) Costs are particularly difficult in urethanes because 1) a large number of ingredients are used, and 2) costs differ with the method of production. Also, prices have been coming down continually.

Materials costs given here (and elsewhere in this article) are for large volume quantities at time of writing; they do not include processing costs. Cost of the basic materials for a fluorocarbon-blown polyether is about 60-70¢ per lb for a prepolymer-type system and about 45-55¢ per lb for a one-shot system. To arrive at materials cost on a volume basis, merely multiply materials cost by density (in lb per cu ft), e.g., a 2-lb per cu ft foam produced by the prepolymer method would be about $1.20-1.40 per cu ft; the same foam produced by a one-shot process would cost about $0.90-1.00 per cu ft. There is negligible loss during the foaming process.

These prices are for standard systems; self-extinguishing foams are higher in price.

Prepolymer vs one-shot

At present, most rigid urethane foams are produced by the prepolymer method. A polyol is partially reacted with an isocyanate and subsequently mixed with the proper catalyst to produce the cellular product. This method is simpler, in terms of number of components, but more costly, in terms of materials cost, than the one-shot system in which the separate ingredients are purchased and mixed at one time to produce the foam. On the other hand, use of prepolymer precludes a great deal of the control necessary in foaming one-shot systems.

Base materials particularly tailored for one-shot foaming of rigid foams are now appearing on the market. But just how widely one-shot methods will be used in the future is still debatable.

On the one hand, proponents of the one-shot method emphasize the lower materials cost of that method, suggesting that the larger companies who could better afford the capital investment necessary to handle and control the materials will probably be the

first to fully use the one-shot system. Smaller companies would eventually follow suit.

On the other hand, prepolymer producers are aware of this squeeze, and many observers expect they will be lowering their prices to compete. This competition, if maintained on a quality-of-material basis, could only benefit the end user.

'Frothing' is promising

A so-called frothing or pre-expansion system for rigid or flexible urethane foams now under development may help solve some of the problems in commercial use of foam.

Essentially, the process, developed by Du Pont, involves adding additional blowing agent, under pressure, to the liquid foam mix just prior to dispensing the foam. The gas partially expands the foam mix, producting a froth of the consistency of shaving lather. With conventional techniques, the foam mixture must expand 30 to 40 times to reach final volume. The froth process reduces final expansion in the mold to only 3 to 6 times the froth volume.

According to Du Pont, the process provides the following benefits:

1. It substantially reduces pressure within the panel or mold during expansion, permitting larger panels to be foamed in one operation.

2. It provides greater consistency of cell size and density throughout a panel, since the foam is almost fully expanded at time of dispensing.

3. Since the froth has good stability of cell structure, it can be knifed smooth or otherwise formed prior to final cure without collapsing the cells.

The primary problem now is the lack of dispensing equipment for froths. The blowing agent is introduced under pressure, requiring a special type of dispensing head for the mix. Reports indicate that commercial utilization of this method may be as much as a year away.

Spraying: still new

Spraying of urethane foam has been discussed for a number of years, and some highly successful installations have been made. Only now, however, does the method appear to be on the verge of broad commercial use. The main applications are for thermal insulation; consequently the fluorocarbon-blown polyethers will probably be most widely used.

Essentially, the foam mixture is simply sprayed on the surface to be coated. The urethane provides good adhesion to most metals, and the mix expands in place to a final thickness of about 2-3 in. Most such applications are now being carried out on a custom-applied basis.

Two major problems have retarded wide use of spraying:

1. A great deal of skill and experience are required to apply the coating so as to end up with a

TABLE 1—A QUICK GLANCE AT FOAM PLASTICS COMMERCIALLY AVAILABLE

Type[a] ↓	General Processing	How Purchased	Density Ranges, lb/cu ft	
			Available	Most Common
Urethane (R)	Liquid systems, mixed to expand; heat cure desirable	Base chemicals; prepolymer mix; custom molded shapes	1.5-30	1.5-2.5; 4-7
Urethane (F)	Liquid systems, mixed to expand; or machined from slab	Foamed slab; machined shapes; liquid systems; custom molded shapes	1.5-30	1.5-2; 4-5
Polystyrene (R)	Expandable beads, heated to form final foam; or prefoamed plank or log, cut to shape	Expandable beads; stock shapes; prefabricated panels; custom machined shapes; custom molded shapes	1.0-15	1.5-2.5; 2-3; 4-10
Vinyl (F, R)	Mixing gas or blowing agent in vinyl plastisol	Custom molded shapes; laminated sheet	5-30	3.5-4
Epoxy (R)	Machined from slab or liquid mix	Stock shapes; liquid systems	2-35[d]	5-25
Polyethylene (F)	Extruded with blowing agent	Stock shapes; extrusion compounds	2-3; 10-30	2; 28-30
Phenolic (R)	Liquid system, mixed to expand	Liquid systems	2-25	2-5
Silicone (F, R)	Liquid systems, mixed to expand, or powder heated to expand	Liquid systems; dry powders; custom molded parts	3.5-9; 12-16	•
Cellulose Acetate (R)	Extruded with flash-evaporated solvent	Stock shapes	6-8	6-8
Urea Formaldehyde (R)	Frothing water-soluble resins	Blocks or shredded form	0.8	0.8

[a] F = Flexible; R = Rigid.
[b] Heat resistance varies radically with different foams; figures here indicate only general order of magnitude usually obtainable.

foam coating of uniform thickness.

2. Foaming is highly dependent on ambient temperature and humidity, as well as temperature of the surface to be coated; this makes outdoor applications, such as coating large tanks, heavily dependent on weather conditions. It is difficult to obtain proper foaming at temperatures below about 70 F.

For many applications, particularly in outdoor use where temperatures may fall below freezing, a coating should be applied to the foam. Because of their low cost, the most common types are asphaltic cut-back mastics. Various types of synthetic elastomeric coatings are also used.

Even for indoor use a protective coating will prevent permeation of moisture and air that would somewhat increase the k factor of the foam.

	General Max Temp, F[b]	Primary Features	Major Uses	Comments
	250-300[c]	Versatility, low k factor, structural strength, low density, excellent adhesion when foamed in place	Low temp thermal insulation; flotation and void-filling; sandwich cores	Large volume use now growing; prices continuing downward
	250-300	Excellent and controllable compression-deflection characteristics, nonstaining, relatively low density and cost	Auto, furniture seating; crash pads; bedding; packaging	Large volume use still growing
	160-185	Low cost, excellent energy-absorption characteristics, low k factor, versatility in forming	Packaging; thermal insulation; flotation; novelty items	Largest volume in building panels and packaging; both uses growing rapidly
	150-170	Noninflammable, excellent compression-deflection, nonstaining, excellent chemical resistance	Public seating; interliners for bags and accessories	Current volume good, though somewhat static; growth retarded by high cost
	250-300	Excellent electrical properties, dimensional stability and strength	Tooling fixtures; electronic potting and radar transmission	Use limited by high density and resulting high cost; new low density foams highly promising
	195	Excellent electrical properties, moisture and chemical resistance	Wire and cable coating; flotation; seals; packaging	Good growth potential beyond electrical and flotation uses
	250	Low cost	Plastic tool cores	Limited in use because of friability and low strength
	300-600	Excellent resistance to heat, and moisture; excellent electrical properties	High temperature potting and encapsulation; molded heat resistant aircraft components; hot pipe and valve insulation	Should continue in high performance, high price applications
	350	High strength	Core for sandwich structures	Limited by high cost to critical structural applications
	120	Light weight, low k factor	Low temp thermal or acoustical insulation	Limited by lack of structural strength and poor moisture resistance

[c]New high temperature urethane reported to be good up to 600 F.
[d]New developmental epoxy foam will be available in nominal density of 2.3 lb per cu ft.
[e]Specialized material; no specific density range most commonly used.

Battle of the refrigerators

The elusive k factor appears to be the key to the battle for refrigerator wall and door insulations. At present, the degree of acceptance of urethane foam over fibrous glass depends on whom you talk to. Opinions differ among the large refrigerator manufacturers. The common goals: 1) reduce wall thickness, thus providing greater storage area for a given outside dimension; 2) provide greater flexibility in design from the styling standpoint; and 3) provide greater strength.

Development people of several large manufacturers feel that foams are the answer for three reasons: 1) their performance at present is such that they offer substantial benefits over fibrous glass; 2) the production problems that increase installed foam cost are being minimized, and future developments will reduce them still further; and 3) materials cost—the major drawback of urethanes—has come down, and will continue down.

Others queried feel that though the potential of the materials is good, systems presently available are too tricky. They say that experience is lacking and much needs to be done in terms of reliability of performance. One observer feels that widespread commercial use might be as far as four or five years off, if all goes well.

Present status—Specific details are difficult to obtain from the manufacturers. The major use of foams so far has been to reduce insulation thickness in gas-operated refrigerators (gas types require more insulation as they are less efficient than compressor types). Some of the large manufacturers are also now producing certain of their electric models using urethane foam. Others are tooling models for production, while still others are putting out only limited numbers of units as "trial balloons." Probably the largest and earliest user of urethane foams in refrigerators re-

ports that about 20% of its units are insulated with the foam.

In those boxes now being made with urethane foam, the fluorocarbon-blown polyether types are used. Wall insulation is foamed in place between the porcelain enameled steel inner and outer faces. Most manufacturers use prepolymer systems, though some formulate their own prepolymers. In producing doors, urethane is foamed in place against the outer steel wall, using a dummy door liner as a mold. After cure of the foam an impact polystyrene liner is applied. (Such foams cannot be foamed against the polystyrene liner because the fluorocarbon blowing agent attacks the impact polystyrene. ABS materials, such as Cycolac, Kralastic or Lustran I, could be used, but at present their price is too high.)

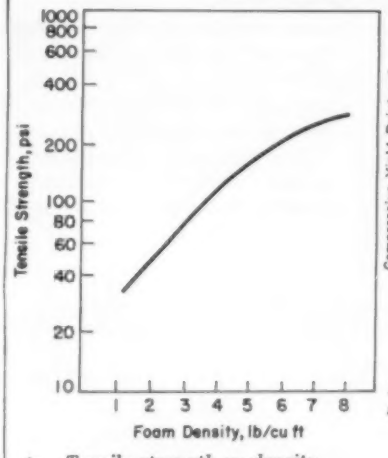
Performance—Refrigerator wall and door insulations use foams of 1.5-2.0 or 2.2-lb per cu ft density, according to manufacturers. Thermal insulation k factors are about 0.12-0.15 Btu/hr/sq ft/°F/in. (vs about 0.28-0.3 for fibrous glass, 0.24 for cellular polystyrene).

The debatable problem is the effect of aging on k factor. Those major producers more involved in using foams report that although all foams age differently, they have been able to find or develop satisfactory foams which, enclosed in the refrigerator wall, retain k factors of 0.15 or less after aging. One manufacturer reports that aging studies on the foams it uses show that the k factor increases to no more than 0.16 when exposed to air and does not increase appreciably above the initial 0.12 value when enclosed in refrigerator walls.

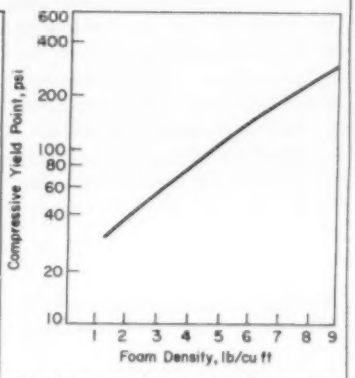
Another manufacturer reports that on its 2-lb per cu ft foams, k factor must not exceed 0.15 Btu/hr/sq ft/°F/in. The company says it maintains this k factor on exposed 1-in. specimens after aging for two years at 70 F and 50% RH.

On the other hand, another major producer says its aging studies have shown the k factor of urethanes to be extremely

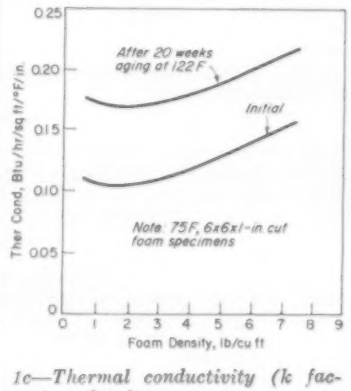
Typical properties of fluorocarbon-blown rigid polyether urethanes . . .



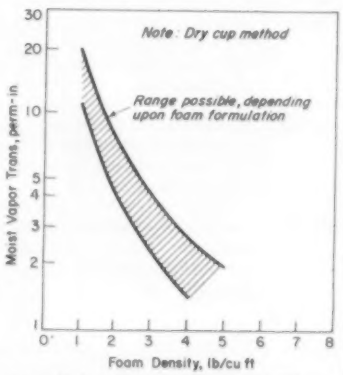
1a—Tensile strength vs density.



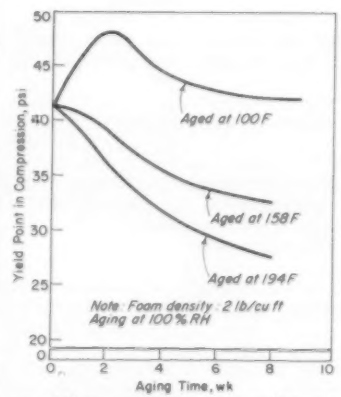
1b—Compressive strength vs density.



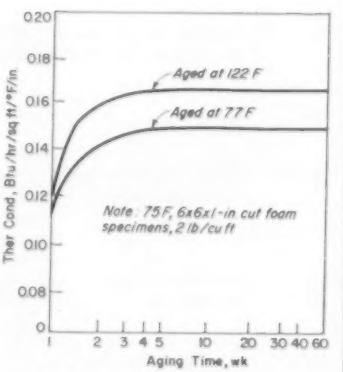
1c—Thermal conductivity (k factor) vs density.



1d—Moisture vapor permeability vs density. Perm-in. = 1 grain of vapor/sq ft/hr/in. Hg pressure differential.



1e—Effect of heat and aging on compressive strength.



1f—Effect of heat and aging on thermal conductivity.

(Source: Du Pont)

tricky and undependable. This company feels that much more work must be done in stabilizing the aging factor.

The fact that urethanes adhere to walls during expansion is listed as a benefit by some manufacturers, since it adds the structural strength of the foam (about 20 psi compressive strength in all directions) to the wall of the box. Others point out that the good adhesion can be a special problem where mold release is necessary, e.g., foaming doors against dummy liners.

Production—One of the most pressing production problems has been the need for additional tooling jigs and fixtures to prevent panel walls from deforming under the pressure of the expanding foam. The consensus among manufacturers is that this is not an insurmountable problem. Some have solved it with tooling innovations; others look to future developments.

Several refrigerator manufacturers are interested in the new frothing or pre-expansion system described above, with the aim of reducing expansion pressures and thus tooling costs. Others who feel they have the tooling problem licked are less enthusiastic.

The problem of possible voids in foam-in-place walls is apparently not a large one. Most manufacturers indicate that with proper foam systems and proper control of preheating, metering and curing, high-quality consistent-density foam walls are commercially producible.

Costs—Basically, urethane is competing with fibrous glass in refrigerator insulation. Fibrous glass costs about 2.5¢ per bd ft (with k factor of 0.3 Btu/hr/sq ft/°F/in.).

Foam prices (2-lb per cu ft density) of $1.20 per cu ft for prepolymer and $1.10 per cu ft for one-shot, result in a board foot cost for urethanes of 10¢ for prepolymer; 7.5-9.2¢ for one-shot. But with a k factor of 0.15, or just half that of glass, costs for the same insulating effect are about 5¢ for prepolymer; 3.8-4.6¢ for one-shot. (These costs do not include compensation for loss of material during foaming. Though some observers indicate that such losses are negligible from the cost standpoint, others point out that practical yield of material is probably about 90%, which could add 8-10¢ per cu ft.)

Although all refrigerator manu-

TABLE 2—TYPICAL PROPERTIES RIGID URETHANE FOAMS[a]

Density, lb/cu ft →		2.0-2.5[b]	4-7	18-25
	ASTM			
Compressive Strength, (10% defl), psi	D1621	25-50	65-150	900-1800
Tensile Strength, psi	D1623	30-50	110-165	700-1200
Shear Strength, psi		20-30	60-130	7600
Ther Cond (k factor), Btu/hr/sq ft/°F/in.		0.11-0.16[c]	0.22-0.28	0.29-0.32
Moisture Vapor Perm, perm-in.	C355	1.5-5	—	—
Water Absorption[d], % by volume		1.2-2.5	1.6	0.2
Max Recommended Service Temp, F		165-250	160-300	250-400

[a] Values given are only intended to indicate order of magnitude; values for specific foams can vary widely.
[b] Values for fluorocarbon-blown polyether foams.
[c] Range covers initial value and aged value; see discussion on refrigerator insulation.
[d] 4 x 4 x 1-in. specimen completely submerged under 10-ft head for 48 hr.

Cellular Plastics— Status of Standard Testing Methods[a]

1. Methods published as Tentative Standards by ASTM:

Materials

Closed Cell Poly (vinyl chloride) Sponge or ' opolymers thereof, Tentative Specifications and Methods of Test for—D1667-59T.

Performance

Apparent Density of Rigid Cellular Materials, Tentative Methods of Test for—D1622-59T.

Compression Strength of Rigid Cellular Materials, Tentative Method of Test for—D1621-59T.

Dielectric Constant and Dissipation Factor of Expanded Cellular Plastics Used for Electrical Insulation, Tentative Method of Test for —D1673-59T.

Flammability of Plastic Foams and Sheeting, Tentative Method of Test for—D1692-59T.

Package Cushioning Materials, Tentative Method of Test for Dynamic Properties of—D1621-59T.

Package Cushioning Materials, Tentative Method of Testing—D1372-55T.

Tensile Properties of Rigid Cellular Materials, Tentative Method of Test for—D1623-59T.

2. Methods under development, or to be developed:

Materials

Expanded cellular polystyrene, specifications for.

Rigid urethane foam, specifications for.

Performance

Electrical properties, e.g., resistance and dielectric strength.

Mechanical properties, e.g., flexure, dynamic modulus, and porosity.

Permanence, e.g., aging at normal and elevated temperatures, humidity aging, coefficients of expansion, creep, fatigue, water permeability and water vapor transmission.

Thermal properties, e.g., conductivity.

[a] List does not include standards on raw materials.

Whirlpool Corp.

Rigid urethane foams *(fluorocarbon-blown polyether type) can result in this type of economy. At right is a comparison of refrigerator wall thickness insulated with glass and with foam; above, dimensions show the resulting increase in internal storage area of a gas refrigerator.*

THERMAL INSULATION: urethane vs polystyrene . . .

Wyandotte Chemicals Corp.

Sprayed urethane foam insulation *is just beginning as a commercial process. Here a 500,000-gal caustic soda storage tank is being sprayed with polyether urethane. Tank has 28,000 sq ft of surface covered with foam; internal temperature is kept at 120 F min.*

facturers queried say that this is still too high, they also say that prices have been coming down, and they are hopeful the trend will continue. The development of practical one-shot systems may help to reduce final price substantially.

How about other foams?—At present all refrigerator manufacturers queried feel that foamed polystyrene at its present stage of development (k factor of 0.24 Btu/hr/sq ft/°F/in.) does not have a future in home refrigerator wall or door insulations. Converted to a board-foot basis, foamed polystyrene costs 6.2¢ for expanded bead, 7¢ for pre-expanded plank (at 2-lb per cu ft density).

However, one manufacturer, more cautious than the rest on urethanes, feels that a breakthrough in k factor of polystyrene

could put it right back in the picture.

A new epoxy foam, though still early in developmental evaluation, may have a bright future. According to refrigerator manufacturers who have evaluated it, the main benefit offered by the material might be lower cost, particularly in comparison with prepolymer urethane systems.

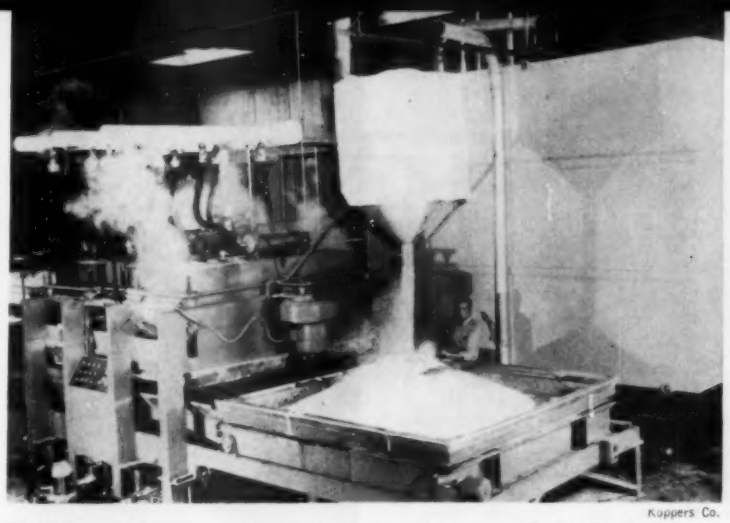
According to a research chemist with one of the major refrigerator manufacturers, the new foam appears to be virtually identical to urethane in insulation performance. However, contrary to the developer's (Shell Chemical Co.) claims, initial evaluation in that manufacturer's laboratory indicates that the material does not provide as good adhesion as urethane.

From the processing standpoint, opinions differ on the new epoxy: One observer feels that it is more difficult to process because of viscosity problems and the accuracy of control required. Another feels that processing may be simplified because only two components are involved.

Reefers face redesign

Refrigerated trucks and trains hauling frozen foods may be in for some radical, costly redesigns. The AFDOUS (Association of Food and Drug Officials of the United States) has adopted a code calling for some rigorous new temperature requirements for shipping and storing of frozen foods, e.g., maintaining maximum temperature of 0 F in transit. If the code is adopted by the states (three states have already made the code a requirement), many refrigerated trucks and railroad cars will have to be modified or rebuilt.

In redesigning such units, use of foam permits maintenance of economical thin walls with no increase in size of refrigerating equipment. Additional benefits include: 1) preventing moisture pickup in service, a factor that can be surprisingly large in long-haul trucks; and 2) providing additional structural strength in the walls.



Koppers Co.

Polystyrene foam . . . *Used for insulating boxcars of Pacific Fruit Express, pre-expanded polystyrene beads are shown being blown into large mold for steam expansion. Developed by R. L. Landis, doors are larger than previous ones and use an ABS plastic liner (Marbon Chemical Co.'s Cycolac).*

Nopco Chemical Co.

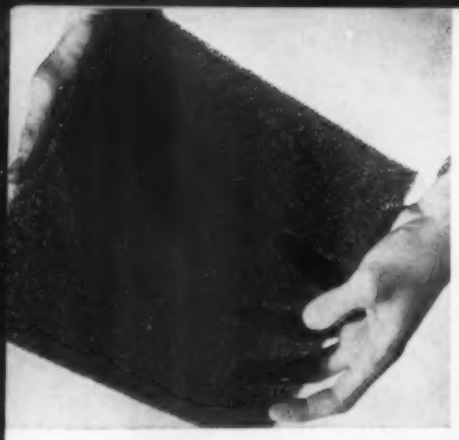
Urethane foam . . . *Used for insulating refrigerated trucks, liquid mix is shown being poured into panels for foaming. Developed by Dynafreeze Corp., panels are used for large trucks. Future of urethane foam for this application may rest on finding a good way to foam-in-place complete panels.*

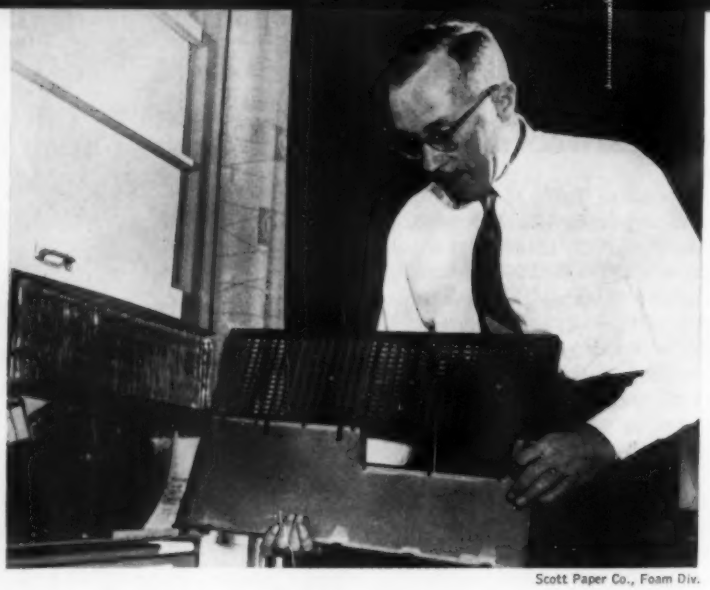
Of the foams available at present, fluorocarbon-blown polyether-type urethanes, and polystyrenes, appear to be hot contenders. Selection of such materials for truck construction, however, is more complex than for mass-produced products like refrigerators. Refrigerated trucks are virtually custom-made. They are produced to the specification of the end user, and these specifications differ radically. Consequently, types of construction differ radically. For some types, foam-in-place processing can be highly efficient; for others, construction with plank-type insulation can be more efficient.

One of the current problems in foaming-in-place urethane insulations in truck panels is the large size of the panels and therefore the height of the pour. Panels are usually so large that the full height of the panel cannot be poured at one time because of the excessive densification, pressure and exotherm that would occur. So the panel must often be poured in stages. The commercial development of frothing or pre-expansion systems may overcome this obstacle.

Filtration: big and growing

Open-cell rigid urethane foams have become widely accepted as filter mediums, particularly in air filtration applications, e.g., approximately 50% of all 1960 room air conditioners used urethane foam filters, according to Foam Div., Scott Paper Co. The filters





***Rigid** polyester urethane foam with skeletal filtering structure shown is used in the grilles of all 37 models of Westinghouse Electric Corp.'s Mobilaire air conditioners.*

Scott Paper Co., Foam Div.

FILTRATION: growing use for rigid urethane . . .

are produced by a special process which leaches out the cell walls of a polyester-type urethane, leaving only connnecting strands.

Featuring high filtering efficiency and cleanability, foams are produced in six standard pore sizes and in thicknesses ranging from 1/16 to 6 in. The material has air flow resistance of 350 fpm (½-in. pad) from 0.045 to 1.0 in. of water. According to Scott, 97% of the material's volume is void, providing enormous dust-holding capacity.

Several makes of 1960 cars are equipped with urethane foam filters as carburetor air cleaners. The material is less expensive than resin-treated paper and has higher efficiency than metallic mesh.

A major producer of lawnmower motors is reported to be evaluating the material for motor air filters. Filters are oil resistant and can be cleaned without matting or separation.

An interesting new foam filter, now under development, is a material that is rigid when dry, softens when washed in soap and water, and becomes rigid again when dried. It is expected to find use in large heating and air conditioning systems.

Other potential applications for foam filters: lint filters in washing machines, and canister filters in gas masks.

Flexible urethanes

Flexible urethanes are somewhat older than the rigid types. The polyether-type flexible foams, with their improved compression-deflection characteristics (compared to earlier polyester types), have become relatively well accepted for comfort cushioning, e.g., auto seating and furniture.

Probably the most important development in flexible urethanes is the generation of meaningful standards and specifications which describe the engineering performance of the materials. Although much more work is yet to be done, substantial progress has been made, primarily through the efforts of the Cellular Plastics Div. of the Society of The Plastics Industry working with the American Society for Testing Materials. Table 3 reproduced from ASTM D1564, outlines standard specifications and physical requirements for flexible urethane foams. Bear in mind that these are minimum requirements; much better values are commonly obtainable.

The most important shortcomings of standard tests for flexible urethanes are probably in 1) shear, where there is need for a dynamic use test that will draw more precise distinctions between quality foams, 2) heat aging, and 3) softness or creep.

Densities of flexible foams most commonly used are: 1.5-2.0 lb per cu ft for comfort seating; 4-5 lb per cu ft for crash pads. A possible future trend in seating may be to use somewhat higher densities but reduce the thickness of the foam to provide the same load-bearing ability. Such a change might be of particular design importance to such users as auto manufacturers interested in the "low look."

Machining vs molding

At present, most flexible urethanes are foamed as continuous slabs from one-shot systems. Cushions, seats, etc., are then machined from the slabs. According to some observers, the biggest new development in flexibles may be the one-shot molding or foaming-in-place of flexible foams. But the comparative cost benefits are not too clearly defined.

In the first place, slab stock is relatively inexpensive. It is pro-

duced by highly economical one-shot foaming methods on a continuous basis. Also, keen competition has driven the price down further. Prices are about 12-15¢ per bd ft at present; some observers indicate that prices below 12¢ have been obtained.

Also, the technology of high speed, automatic equipment for cutting and machining slab stock is highly developed, minimizing machining costs. When molding a product such as a seat, an inventory of several molds for different designs must be maintained.

With the development of the newer approach of designing a product to make full use of the capabilities of urethane foam, molding in place may become much more widely accepted. Important benefits here would accrue from foaming in place around other components, such as auto springs, to produce a composite product of maximum performance and minimum cost. This is discussed in more detail in the next section.

TABLE 3—ASTM PHYSICAL REQUIREMENTS FOR FLEXIBLE URETHANE FOAMS (D1564)

Grade Number ↓	Load for 25% Defl (50 sq in.), lb[a]	Compr Set (const defl, 22 hr, 158 F, 50% defl), max %		Effect of Steam Autoclave (3 hr, 220 F)		
		C_h[b]	C_d[b]	Compr Load Defl Loss, max %	Compr Set (const defl, 22 hr, 158 F, 50% defl), max %	
					C_h[b]	C_d[b]
CORED[c]						
UC 10	10 ± 3	10	20	20	15	30
UC 15	15 ± 4	10	20	20	15	30
UC 20	20 ± 4	10	20	20	15	30
UC 25	25 ± 5	10	20	20	15	30
UC 30	30 ± 6	10	20	20	15	30
UC 35	35 ± 7	*	*	*	*	*
UC 40	40 ± 7	*	*	*	*	*
UC 50	50 ± 8	*	*	*	*	*
UC 60	60 ± 9	*	*	*	*	*
UNCORED[d]						
UU 10	10 ± 3	10	20	20	15	30
UU 15	15 ± 4	10	20	20	15	30
UU 20	20 ± 4	10	20	20	15	30
UU 25	25 ± 5	10	20	20	15	30
UU 30	30 ± 6	10	20	20	15	30
UU 35	35 ± 7	*	*	*	*	*
UU 40	40 ± 7	*	*	*	*	*
UU 50	50 ± 8	*	*	*	*	*
UU 60	60 ± 9	*	*	*	*	*

[a] Rubber Manufacturers Assn. buyers' specification designation.

[b] C_h = % original height; C_d = % original deflection.

[c] Cored—Indentation load deflection tests on molded or fabricated articles either cored or uncored are performed using the entire product sample as the test specimen as covered in D1564, Test Specimens.

[d] Uncored—Indentation load deflection limits as shown in the table for uncored sheet, slab or block products are based on a standard thickness of 2 in. Bear in mind that any given foam will yield a lower indentation load deflection value when measured at a lesser thickness. If values for thickness other than 2 in. are desired the thickness shall be agreed upon between the supplier and the purchaser.

[e] Values to be assigned later.

Source: Adapted from ASTM D1564.

Auto seating revolution?

According to *Wall* of Inland Mfg. Div., General Motors Corp., auto seat cushions that utilize the unique properties of urethane foam have not as yet been produced in any volume. So far, he points out, urethane foam has been used as a substitute for existing materials, e.g., foam rubber in topper pads, and curled hair. It has not been used in a proper design making use of all the material's potential.

Wall goes on to compare past conventional seat construction with possible construction if the seat were designed for urethane foam. In the conventional seat construction, there are eight materials: 1) trim, or upholstery, 2) No. 1 cotton pad, 3) latex foam rubber cored pad, 4) No. 3 cotton pad, 5) Young wire insulator, 6) zig-zag springs, 7) jute spring silencer, and 8) trim tape.

Most present seats utilizing urethane foam merely substitute the foam for the foam rubber cored pad. Wall goes on to describe the possible evolution of the seat to the point where it consists of only three components: 1) a slush molded or vacuum formed vinyl trim or upholstery, 2) urethane foam molded to the skin, and 3) zig-zag springs molded in place in the foam.

At present, several manufacturers are reported to be molding flexible foam seats with springs integral in the foam. A similar approach is the foaming in place of resilient urethane within a slush-molded vinyl skin for auto arm rests.

All-foam furniture next

A process developed by General Tire and Rubber Co. for Karpen Furniture permits production foaming of an entire upholstered chair integral with its frame. In this process a rigid tubular steel frame is positioned in a mold cavity and a flexible polyether formulation is poured into the mold and allowed to foam (requiring several seconds).

After the unit is removed from the mold, legs are screwed on and upholstery added.

The process is said to combine complete freedom of design with economical high volume production techniques.

Bedding and clothing

Flexible urethane foam mattresses and pillows have been successfully used in institutional bedding for a year or more. Penetration into consumer bedding has only begun, but should grow rapidly. Briefly, urethane foam for bedding offers: 1) light weight—some mattresses now used weigh only 12 lb; 2) sanitation—it can be easily cleaned and, if necessary, autoclaved at 280 F; 3) safety—nonflammable types are available; and 4) long-life comfort—it will not bunch, wad or pack, and it is inert to water, chemicals, disinfectants and oils.

The use of foams as thermal insulating interliners for clothing has been substantially boosted by the development of flame bonding. In flame bonding, a thin (1/16-1/8 in.) sheet of open-cell flexible urethane foam is passed rapidly over an open flame, and applied immediately to a fabric. Adhesion is excellent, and the fabric retains its two-way stretch with its original hand and no trace of boardiness. Porosity of the foam is not affected. The result is a lightweight, efficient insulating lining for outdoor clothing. The process is applicable to any fabric, but is of special interest with loose-woven, knitted or nonwoven types.

At present most such interliners are of polyester-type foam, as flame bonding can be used only with this type.

Polystyrene foams

To engineers and designers, probably the most important developments in foamed polystyrene are the new forms in which the material is available, and the design possibilities provided by use of newer forming techniques. Accompanying these developments has been substantial refinement in the engineering of applications for foamed polystyrene.

Table 4 lists typical properties of foams made from expandable beads, as well as properties of pre-expanded logs or planks. Standard grades will burn, but self-extinguishing types are available. Common densities used for various applications are: 1.0-2.5 lb per cu ft for thermal insulation components in panels, boards or parts; 2-3 lb per cu ft for toys and other more durable mechanical parts; and 4-10 lb per cu ft in extruded sheet or film for cups, etc.

TABLE 4—TYPICAL PROPERTIES OF FOAMED POLYSTYRENE

		Expandable Bead Foam		Boards	
Density, lb/cu ft →		1-2	3-5	1.6-2.0	4.3-4.7
	ASTM				
Compressive Strength (10% defl), psi	D1621	14-27	52-92	16-32	120-140
Compressive Modulus, psi	D1621	280-550	1100-2200	1200-1700	4800-5300
Tensile Strength, psi	D1623	31-48	101-128	45-61	170-185
Tensile Modulus, psi	D1623	360-740	2500-6100	—	—
Flexural Strength, psi	[a]	50-75	128-260	42-61	150-170
Flexural Modulus	[a]	1700-3800	6400-13,500	1000-1285	2800-3100
Water Vapor Transmission, perm-in.	C355	1.7-1.2	0.7-0.5	1.0-2.0	1.0-2.0

[a] MIL-P-19644.

Polystyrene foams with a degree of resilience have been developed relatively recently. Although engineering data are unavailable as yet, such foams should provide additional design flexibility in such applications as packaging.

Limited work has been done on combinations of expandable beads and liquid resin systems. One type, making use of beads and liquid epoxy resins, has been under development for the past several years. Some observers feel that other combinations of partially expanded or fully expanded beads with various resin systems could provide foams with unusual and highly useful performance characteristics, possibly for such applications as low temperature insulation.

Cost—Expandable beads cost about 37-40¢ per lb in large quantities. Materials costs for foamed parts of densities of about 2 lb per cu ft would be 74-80¢ per cu ft, disregarding scrap losses. Pre-expanded polystyrene foams cost approximately 85¢ per cu ft. These figures, of course, do not include forming or fabrication costs. Self-extinguishing grades are somewhat higher.

New forms available

Developments in processing of cellular polystyrene have resulted in availability of new forms of the material for the end user. Possibly the more interesting of these forms are extruded film or sheet, lay-flat tubing, and pipe.

In films of 6-10 mils the material has a density of about 4-10 lb per cu ft. Cost at 6-mil thickness is 3.3¢ per 1000 sq in. Although few engineering data are available as yet, the material appears to have a large potential use in packaging.

Essentially, it provides a rich satin appearance and the feel of a soft fabric. Coupled with attractive appearance is resilience to provide protective cushioning. The material has the basic low thermal conductivity of foamed polystyrene (i.e., 0.24 Btu/hr/sq ft/°F/in.).

The film can be vacuum or pressure formed, though matched metal forming is more desirable where high dimensional accuracy is required. Forming temperature is about 220-230 F.

New forming techniques

Use of forming techniques, new to foamed plastics, may provide foamed polystyrene with an even wider design potential than it presently offers. The more interesting of these techniques, now

in various stages of development are 1) injection molding of beads, 2) thermoforming of sheet and film, and 3) blow molding.

Injection molding of expandable beads is now being used to a limited degree to produce such parts as ice buckets. According to Dow Chemical Co., the beads can be mixed with polystyrene molding compounds or reground polystyrene to reduce materials costs. The result is a cellular part with a smooth, continuous polystyrene skin. A variety of decorative effects can be incorporated in the skin. Additional development work is still required.

According to some observers, the method has two drawbacks at present: 1) only relatively high densities can be produced (e.g., 15 lb per cu ft); and 2) cycle time is not short enough to provide the inherent high production benefits of injection molding, e.g., cycle time is said to be about comparable to that of steam chest molding of polystyrene foam.

Thermoforming of cellular polystyrene film and sheet is now being done commercially. Effects vary widely from embossing to relatively deep draws, as in certain types of drinking cups.

Cellular polystyrene has been experimentally blow molded. Development work is at an extremely early stage. At present, moisture vapor transmission is too high for liquid packaging applications.

A processing trend that should be mentioned here is the production of foamed polystyrene in much larger moldings. For example, insulation panels for railroad cars are being molded in one piece as is an entire 11-ft hull for a sailboat.

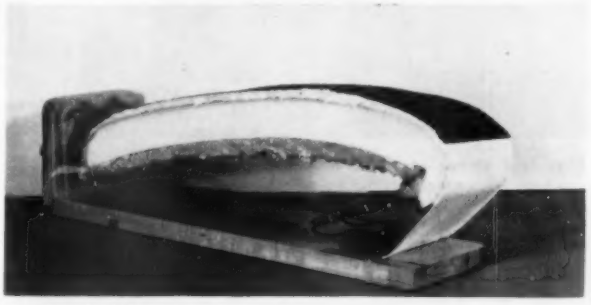
Packaging: cost the key

The use of polystyrene foam in packaging is not new. But next to building and architectural uses it represents the biggest use of cellular polystyrene and is expanding rapidly. The material is used where low cost is important in 1) protection of delicate parts and components, 2) decorative point-of-purchase displays, and 3) thermal insulation packaging.

Inland Mfg. Div., General Motors Corp.

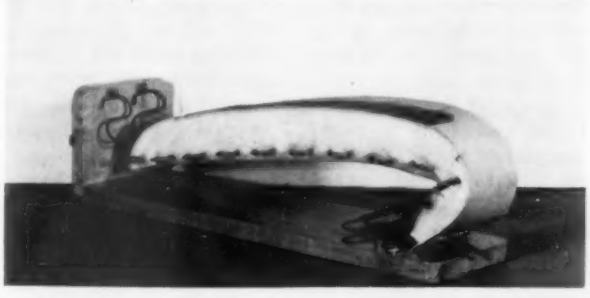
Auto seating: From this . . .

Conventional seat: 1) trim, 2) cotton pad, 3) foam rubber cored pad, 4) cotton pad, 5) wire insulator, 6) zig-zag springs, 7) jute spring silencer, 8) trim tape.



Through this . . .

Constructions now using foam: 1) trim, 2) cotton pad, 3) urethane foam pad replacing foam rubber, 4) cotton pad, 5) wire insulator, 6) zig-zag springs, 7) jute spring silencer, 8) trim tape.



To this . . .

Proposed construction: 1) trim, vacuum formed or slush molded, 2) urethane foam, molded to skin, 3) zig-zag springs, molded in place.

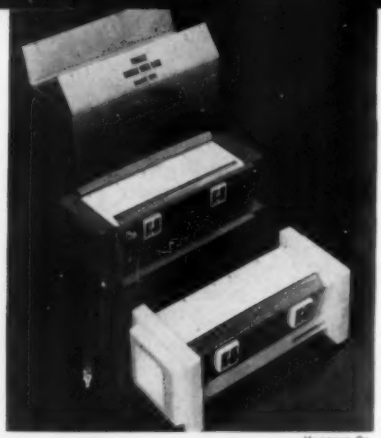
Proposed construction shows possible elimination of five components through redesigning to make full use of potential of urethane foam. Second construction shows common method now used, i.e., where urethane is used merely as a replacement.

PACKAGING:

innovations in polystyrene broaden already large use . . .

Dyna-Foam Corp.

Foam film and sheet *of polystyrene can be thermoformed to provide variety of types of packages incorporating protection from thermal and mechanical shock.*



Koppers Co.

Dow Chemical Co.

Molded end caps *(top) replace corrugated cushioning in package made by Holyoke Custom Moulded Products, Inc., for Puritron Corp. air purifier. Protection for Bell & Howell cameras is provided by molded cocoon-type package.*

Rigid polystyrene foam provides excellent energy absorption characteristics for protective packaging. The lack of resilience, or springback, is highly desirable. On the other hand, once compressed, the material does not recover, and protection for the second shock load is reduced. Newly developed resilient polystyrene foams may fill this gap, i.e., gradually recover after deflection.

With the processing developments mentioned above, and the ability to mold larger and larger shapes, the packaging potential of polystyrene foam has substantially increased.

Low temperature insulation

Although present indications are that cellular polystyrene has lost out to urethanes in home refrigerator wall and door insulations, there appears to be a sizable market open to it in three areas: 1) molded or precut insulations for certain types of refrigerated truck, train and storage facilities, 2) molded components for refrigerators, freezers and air conditioners, and 3) pipe insulation.

In those refrigerated trucks or boxcars where foam is being used, fabrication techniques include: 1) prefabricating panels from board stock; 2) molding or foaming-in-place panels, of either polystyrene or urethane; and 3) foaming urethane in place in the assembled unit. No method has become standardized as yet. Problems in cost or technology exist in each method.

The main factor working for polystyrene is low materials cost. It will probably continue to provide important benefits in those constructions that make use of prefabricated or molded panels, and where polystyrene's thermal conductivity is sufficient.

Current developments in processing of cellular polystyrene may stimulate even further use of the material in molded refrigerator, freezer and air conditioner components. Such developments as profile extrusion and dielectric heating for shorter cycle times can substantially reduce part cost.

News of other foams

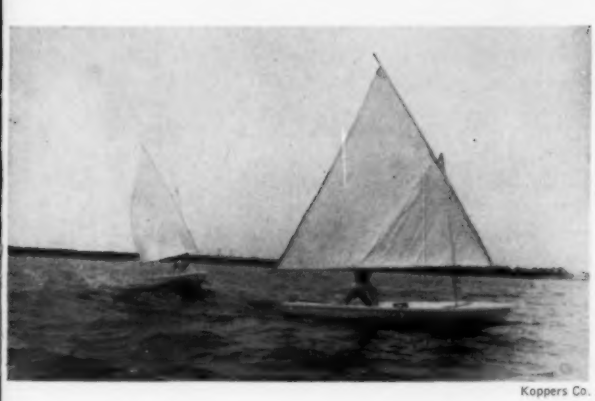
Here are some important developments in other types of plastics foams.

New epoxy promising

An important limitation of previous epoxy foams has been the difficulty in producing a low density foam commercially with reproducible high quality. Common minimum densities have been around 5 lb per cu ft.

The new epoxy, mentioned in the section on urethane refrigerator insulation, is a two-component fluorocarbon-blown system which can be foamed in place to installed densities of 2.0-2.5 lb per cu ft. Performance as low temperature insulation is reported to be directly comparable to that of urethanes.

Still under development, the material is being kept under tight proprietary wraps at present by Shell Chemical Co. According to Shell, primary advantages of the system are excellent adhesion, ex-



Koppers Co.

***Polystyrene foam** is used to mold the entire hull of this 11-ft Snark, produced by Worcester Moulded Plastics Co. The hull weighs less than 30 lb.*

Dow Chemical Co.

***Polystyrene foam** is replacing many metal barrels, as in this diving raft. It is lightweight, puncture proof, permanent, and has high flotation.*

Du Pont

***Urethane foam** is used in this Hunter reinforced plastic powerboat for both flotation and structural rigidity. Produced by Marscot Plastics, Inc., the units have rigid urethane foam foamed in place under the floor, completely filling the bilge.*

FLOTATION: another large use, still growing . . .

tremely low moisture absorption, and excellent stability and structural strength.

It is still too early to say just how the new material will fare. At an introductory price of 60¢ per lb for base materials (65¢ for self-extinguishing types), the material appears to be primarily competitive with prepolymer urethane systems for insulation.

Although some observers feel that future price developments may be the deciding factor, Shell believes that the battle between urethane and epoxies will be decided on the basis of performance in those cases where both are applicable. Shell is confident that epoxy foams will maintain a competitive price with urethane systems over foreseeable cost developments.

Although Shell is obviously aiming initially at use as low temperature insulation, the material is said to be highly versatile. It can be produced in a range of densities, and the base resin can be substantially modified, leading to a wide range of performance capabilities. For example, the material's excellent adhesion and low moisture absorption might make it an excellent sprayable insulation.

At time of writing, no additional information is available on these materials. More specific data should be forthcoming within the next few months.

Cellular polyethylene

At present, all cellular polyethylene commercially available is produced from Type I resins (i.e., 0.910-0.925 specific gravity). Cellular types are either low in density (i.e., about 2 lb per cu ft) for flotation, packaging and sealing applications, or high in density (i.e., about 28-30 lb per cu ft) for insulation of cable such as coaxial or TV lead-in wire.

Cellular polyethylene that might be made from Type III resins (0.95-0.96 specific gravity) is of great interest for uses demanding greater toughness, resilience and heat resistance. Main problems appear to be 1) producing such foams with no residual blowing agent, and 2) obtaining consistent reproducible cell size and distribution.

Cellular polypropylene

Work is now underway evaluating cellular polypropylene. Primary interest is in expanding the areas of electrical use now held by cellular polyethylene, i.e., electrical cable insulations where additional strength, resilience, heat resistance or chemical resistance are required.

Silicone foams

Silicone foams, specialized high cost materials for extreme service, have been primarily available as powders that expand on heating. Newer rigid, semirigid and flexible foams are now available as two-component liquid systems requiring only mixing and a room temperature cure. Such foams can be produced in relatively low densities of 3.5 to 9 lb per cu ft, compared with the relatively high densities of previous silicone foams, i.e., 12-16 lb per cu ft.

Table 5 lists typical properties

of the newer foams. Flexible foams are expanded silicone rubbers. Cost is in the $5-10 per lb range for base materials, depending on volume.

The materials are primarily used where their exceptional heat resistance (rigids and semirigids useful at 600-700 F; flexibles at 300-400 F), electrical insulating characteristics, moisture resistance, and flame resistance are mandatory.

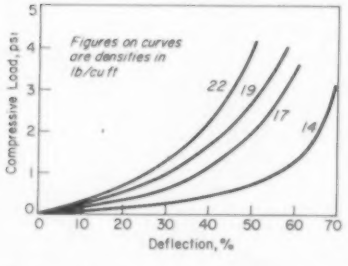
A relatively new development is fibrous silicone rubber which results in an open, porous, matted structure. Compressed - deflection curves for various densities are shown in Fig 2. The material has greater resistance to compression set than silicone rubber foam. It is produced in densities of 20-30 lb per cu ft. Possible uses include sterilizable cushioning, high temperature thermal insulation, high or low temperature seals and gaskets, and laundry and dry cleaning press pads.

A word about the rest

As shown in Table 1, four other types of plastics are available and being used in cellular form.

In brief, here's how they stand:

Vinyl foam—Being used in relatively large volume as public seating (e. g., auditoriums, taxi jump seats and subway seating), flexible vinyl foams have been retarded in growth by their relatively high cost, i.e., about $2.50 per cu ft for low densities (3.5-4 lb per cu ft). Both flexible and rigid materials are available, but new developments have been limited.



2 — *Typical compression - deflection curves for fibrous silicone rubber mats at four different densities.* (Russell)

Phenolic foam—One of the earliest of the foam plastics, phenolic foam is a low cost (about 30¢ per cu ft) rigid foam, with relatively good heat resistance. Friability, low strength, and the corrosivity of acid catalysts used have limited it to specialized applications, such as lightweight cores for plastics tools.

Cellulose acetate—A relatively high strength cellular material, its high cost (about $7-10 per cu ft) has limited its use to specialized structural sandwich materials.

Urea formaldehyde—An extremely low density material, cellular urea formaldehyde has limited uses as thermal insulation in conjunction with other materials. It is exceptionally low in strength; cost is about 80¢ per cu ft.

TABLE 5—TYPICAL PROPERTIES OF NEWER SILICONE FOAMS
(Liquids Mixed, Expanded and Cured at RT)

Density, lb/cu ft ➡	Rigid 3.5	Semirigid 3.5	Flexible 7-9	Flexible 14-16
Closed Cells, %	10	10	10	30
Ther Cond, Btu/hr/sq ft/°F/in.	0.28	0.28	0.31	0.36
Compressive Strength, psi				
Room Temp	900	280	—	—
After 24 Hr at 700 F*	1020	320	—	—
Compression-Deflection, psi				
Stress for 25% Deflection	—	—	1	2
Stress for 50% Deflection	—	—	3	5
Weight Loss (200 hr at 500 F), %	6.4	7.6	9.4	8.6
Volume Loss (200 hr at 500 F), %	8.3	9.1	7.5	5.9
Compression Set (22 hr at 340 F), %	—	—	105	105
Dielectric Constant (10^5 cps)	1.09	1.10	1.17	1.27
Dissipation Factor (10^5 cps)	0.0028	0.0103	0.0010	0.0013
Volume Resistivity, 10^{12} ohm-cm	—	—	3.8	8.7

*Tested at room temperature.
Source: Dow Corning Corp.

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SILICONE NEWS

for design and development engineers • No. 81

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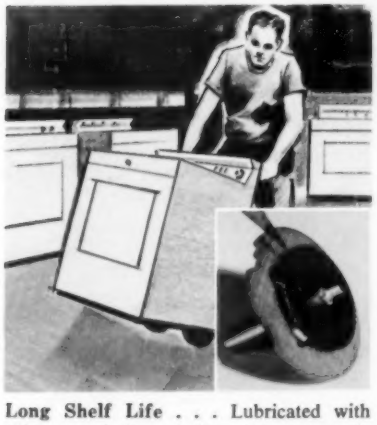

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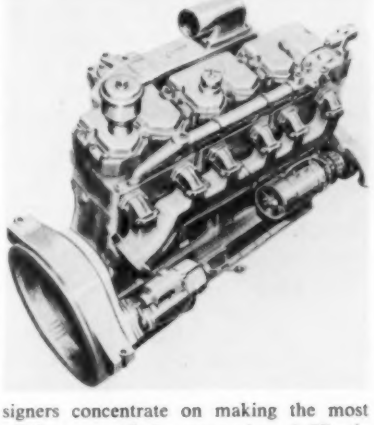

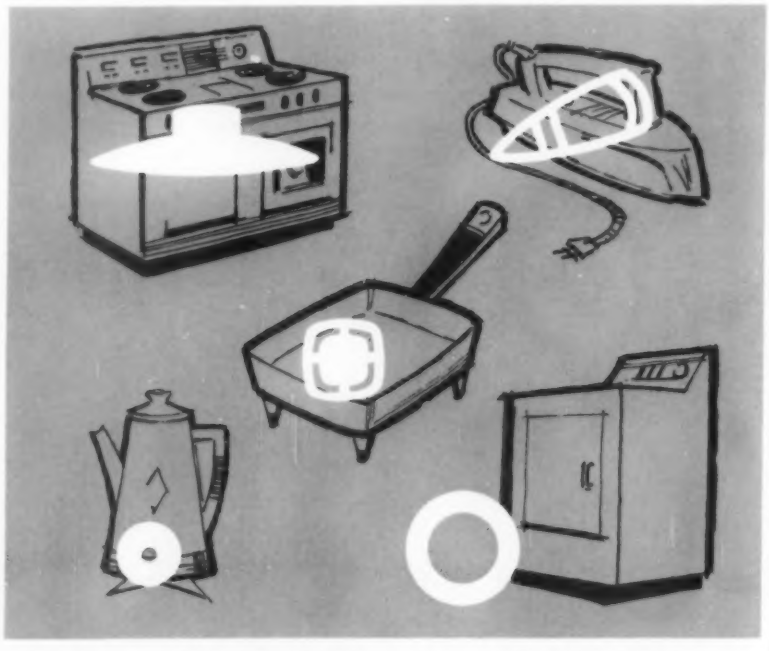

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For list of these suppliers and more information about Silastic, circle . . . *No. 243*

new literature and technical data on silicones

New Molding Compound for 700 F electrical uses features long term stability, excellent resistance to thermal shock, low dissipation factor and good arc resistance. The history and properties of this mineral-filled silicone molding compound, which was developed especially to meet stringent performance requirements, are presented in an article from a recent issue of MATERIALS IN DESIGN ENGINEERING. To obtain a copy, circle . . . . . *No. 244*

Compiled for Advance Research and development engineers, an eight page reference provides a convenient guide to selecting the most suitable silicone fluid medium when designing damping, springing, coupling and related mechanical devices. Includes tables, graphs and detailed information about properties that enable Dow Corning silicone fluids to increase efficiency of existing designs and make possible new design changes. *No. 245*

Four Simple Steps to making silicone rubber molds for short run castings are described in an article reprinted from PRODUCT ENGINEERING. Silastic RTV, the fluid silicone rubber that cures at room temperature, makes it possible to produce flexible molds and patterns for casting metal or plastic parts, even with most intricate detail, cheaply and quickly. An ideal means of making prototype parts. *No. 246*

Silicones in Appliances can give that extra edge for extra sales. This colorful booklet tells where and how silicones are being designed into appliances to give more efficient and reliable performance. It shows how planning around silicones can make good products better. *No. 247*

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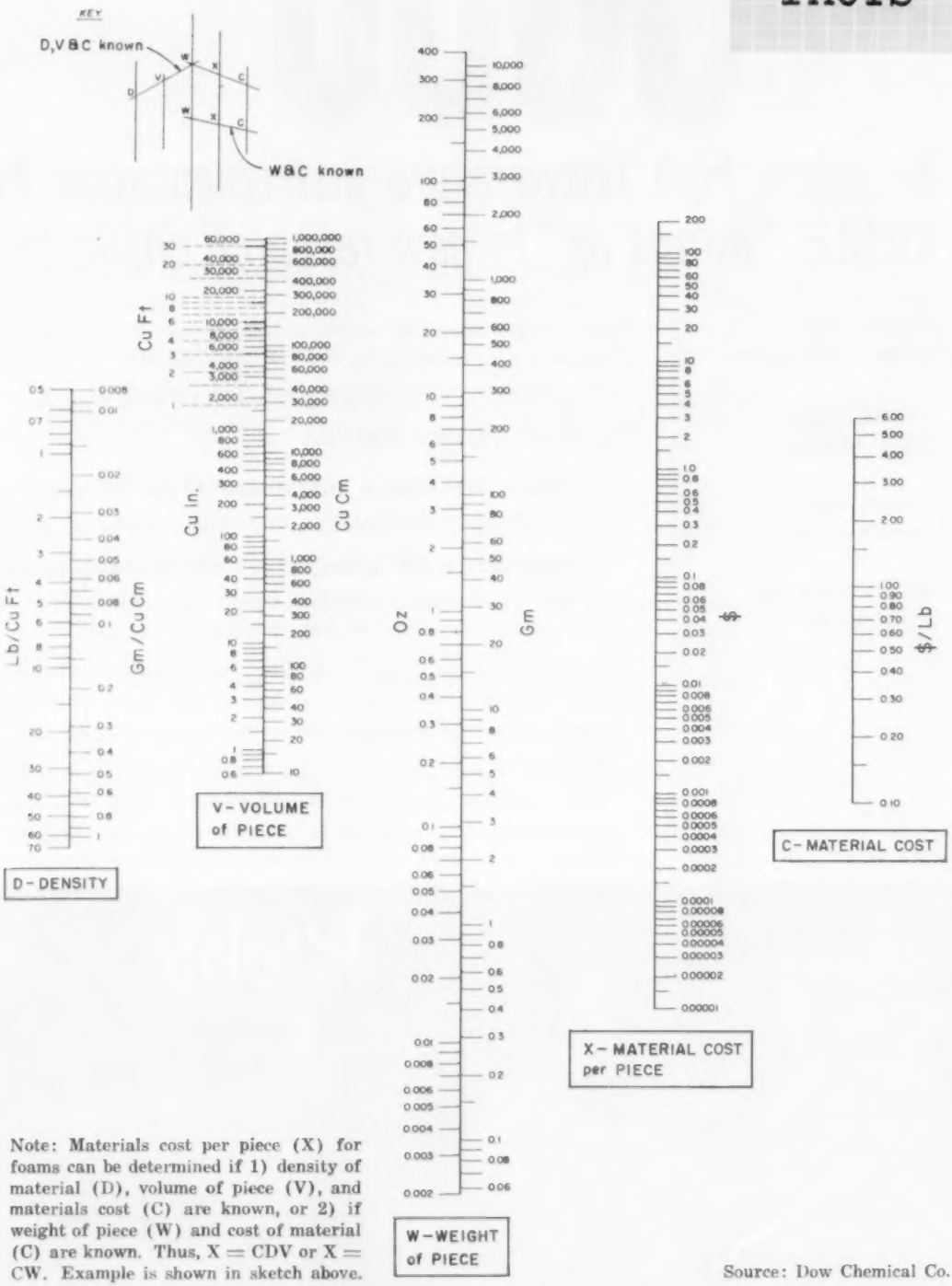
Nomograph: Materials Cost per Piece for Plastics Foams (Density range 0.5 to 70 lb per cu ft)

FILE FACTS



Note: Materials cost per piece (X) for foams can be determined if 1) density of material (D), volume of piece (V), and materials cost (C) are known, or 2) if weight of piece (W) and cost of material (C) are known. Thus, X = CDV or X = CW. Example is shown in sketch above.

Source: Dow Chemical Co.

Up Another 1000° to

5000 °F

Complete high temperature instrumentation by RIEHLE® *"warms up" to new research challenges*

CREEP AND STRESS RUPTURE TESTING MACHINES

HYDRAULIC FATIGUE TESTING MACHINES

HYDRAULIC UNIVERSAL TESTING MACHINES

UNIVERSAL SCREW POWER TESTING MACHINES

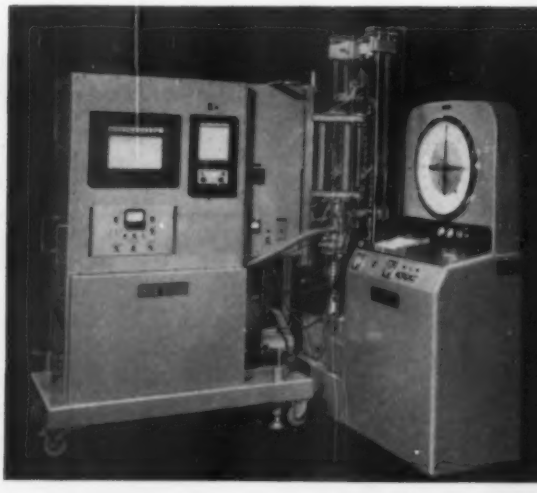
Typical arrangement of Riehle Testing Machine with High Temperature Vacuum Furnace Console for up to 5000° F.

Now RIEHLE offers you ready-to-operate systems for testing physical properties of materials up to 5000° F, 4000° F, 3000° F and other lower temperatures incorporating all of these components:

1. **BASIC TESTING MACHINE**
2. **STRAIN MEASURING INSTRUMENTATION** for atmosphere, controlled atmosphere furnaces and vacuum furnaces.
3. **COMPLETE HIGH TEMPERATURE ACCESSORIES** including furnaces, temperature controllers, vacuum pumps, extensometers and a complete line of related instrumentation.

RIEHLE is your ONE source for complete strain measuring instrumentation from room temperature snap-on extensometers to dual range instruments and highly sophisticated vacuum furnace extensometers.

Save time on vital projects. Contact RIEHLE now about your requirements for physical testing at elevated temperatures. Write Dept. MDE-361



Riehle®

RIEHLE TESTING MACHINES DIVISION OF

American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

"One Test is Worth a Thousand Expert Opinions"

Divisions of American Machine and Metals, Inc.

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For more information, turn to Reader Service card, circle No. 452

PRICES AND SUPPLY

...AT A GLANCE

A 20% cut in the price of Delrin acetal resin has been announced by Du Pont. New price is 65¢ per lb in truckload quantities. This is the third price reduction since introduction of the resin in January, 1960 at 95¢ per lb.

Commercial availability of cesium metal has been announced by U. S. Industrial Chemicals Co. The company says it can produce 50 to 75 lb of the metal per week. Price: $540 to $575 per lb. The reactive metal is currently being used in electronic devices and chemical process equipment.

A new supplier of polypropylene resins is Texas Eastman Co. The company says its Longview, Tex. plant is now in commercial production and will achieve a capacity of 20 million pounds per year by mid-1961. The plastic will be sold under the trade-name Tenite.

A 10% cut in the price of type 422 stainless steel mill products has been announced by Crucible Steel Co. of America.

Production of a new polyvinylidene chloride coating resin for use on paper, paperboard and fabrics has been announced by National Starch and Chemical Corp. Initial plant capacity is rated at 14 million pounds per year. The coating resin, called Resyn 3600, was introduced last spring (M/DE, June '60, p 6).

A 33% increase in tantalum production has been announced by National Research Corp. The company produces capacitor and melting grades of tantalum powders, as well as tantalum wire, foil, sheet, tube, rod and other mill products.

More man-made natural rubber (cis-polybutadiene) will be available when Goodrich-Gulf Chemicals, Inc. opens a new plant at Institute, W. Va. The unit is expected to be in operation by the end of this year and will have an initial output of 20 million pounds. Goodrich-Gulf calls the rubber Ameripol CB.

Wire, rod and other parts made of rare earth materials are now available from Dresser Products, Inc., Great Barrington, Mass. Immediately available are fabricated forms of high purity praseodymium, neodymium, samarium, europium, terbium, gadolinium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium and yttrium, as well as oxide mixtures of these metals.

Wider aluminum sheet and larger aluminum ingots are becoming available. Reynolds Metals Co. says it is now producing what it claims to be the "world's widest" aluminum coiled sheet and plate. Plate is made in widths up to 165 in., sheet up to 115 in. Kaiser Aluminum & Chemical Corp. says it has made the "largest aluminum ingots ever poured." They weigh 14,000 lb and measure 14 ft long, 4½ ft wide and 1¼ ft thick. The large aluminum ingots are rolled into plate, then fabricated into nuclear reactor parts.

Highly complex shapes,

internal and external, formed in one operation to close tolerances in

ALSIMAG® CERAMICS

NEW SHAPES NOW PRACTICAL

Technical ceramic parts formerly impossible or available only by expensive machining and grinding are now practical and can be produced in volume to close tolerances and with great uniformity. They include complex and compound curves, thin walls and other difficult design features. This injection molding process is particularly suited to volume production which readily permits amortization of initial tooling costs.

MATERIALS

AlSiMag 614 (High Alumina) and AlSiMag 704 (Porous and Leachable) have found widest use. Other AlSiMag ceramic compositions are available. See Property Chart, sent on request.

APPLICATIONS

include but are not limited to:

Electronic and Electrical, such as conical micro-wave tube windows, envelopes, complex internal insulators, cups, encapsulating devices, semi-conductor assembly boats and plugs.

High Temperature, Mechanical and Heat Shock uses such as welding nozzles.

Precision Investment Casting cores of great dimensional accuracy.

Guides for wire and textile machinery.

The use of these AlSiMag ceramics is indicated when high frequencies, high temperatures, heat shock, chemical attack or mechanical wear are involved.

EXPERIENCE

More than two years of steadily increased production from this equipment has given us practical experience which enables us to promptly and accurately answer most inquiries involving complex and difficult shapes. Send blue prints or sketches. Chances are that your "impossible" designs are now practical in AlSiMag ceramics.

A Subsidiary of Minnesota Mining and Manufacturing Company

AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENN.
60TH YEAR OF CERAMIC LEADERSHIP

For service, contact American Lava representatives in Offices of Minnesota Mining & Manufacturing Co. in these cities (see your local telephone directory): Boston: Newton Center, Mass. • Chicago: Bedford Park, Ill. • Cleveland, Ohio • Dallas, Texas • Los Angeles, Cal. New York: Ridgefield, N. J. • Philadelphia, Pa. • St. Louis, Mo. • St. Paul, Minn. • So. San Francisco, Cal. • Seattle, Wash.
All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

BOOTH 4401 at I.R.E. **Also see our Titania and Barium Titanate Specialists at Suite 1700, Commodore Hotel, during I.R.E.**

Prices of Materials

*Changes since last semi-annual report in September are bold-faced; *indicates a price decrease*

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.68	.45-.54
Butadiene-Styrene	.14-.30	.26-.32
Butyl	.23-.28	—
Kel F	15.0	—
Natural[a]	**.30***	**.37***
Neoprene[b]	.39-.75	.37-.50
Polysulfide[b]	.50-1.25	.80-1.25
Silicone[b]	1.90-4.00	—
Urethane	1.15-1.65	—
Viton	10.0-13.0	—

[a]Spot price for end of February.
[b]Less than carload quantities for dry rubber.

REINFORCED PLASTICS LAMINATE SHEET

Type	0.025-¼ In.	⅜-2 In.
Paper-Base Phenolic (X, P, PC, XX, XXP, XXX, XXP)	**.90*-1.20***	.82-1.22
Cotton Fabric-Base Phenolic (C, CE, L, LE)	1.20-**1.90***	1.36-1.76
Asbestos-Base Phenolic (A, AA)	1.20	.96-2.70
Glass-Base Phenolic (G-3)	3.25	2.60
Glass-Base Melamine (G-5)	**2.50***	2.30
Glass-Base Silicone(G-7)	**6.50***	5.90
Nylon-Base Phenolic (N-1)	**3.90***	3.54

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.43-.60	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.35	.17-.34
Polyester	**.26*-.39**	.33-.53
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.34	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compound: Base	Molding Compound: Per Cu In. As Molded, ¢[a]	Sheet (.030-.250)	Rod (⅛-¼)	Tube (⅛-¼)
Acetal	**.65 ***	3.3	—	—	—
Acrylic	.46-.55	1.8-2.3	.49-2.15	.90-1.15	1-1.15
Chlorinated Polyether	2.50	12.6	—	—	—
Cellulosic					
Acetate	.36-.58	2.1-2.8	.92-1.16	.75-1	.85-1
Butyrate	.40-.62	2.0-3.0	1-1.28	.95-1.20	1.05-1.20
Nitrate	—	—	1.60-2.73	1.45-1.75	2.25-5.00
Propionate	.62	2.7	—	—	—
Fluorocarbon					
CFE	7-8	53.0-61.0	15-23	18-22	20-22.50
TFE	**3.25*-5.00***	25.0-38.5	11-14	13	13
Nylon	.98-2.18	4.0-9.0	—	3	3
Polycarbonate	**1.30*-1.75***	5.6-7.5	—	—	—
Polyethylene	**.27*-.38**	0.90-1.3	.85-1	.75-1	.85-1
Polypropylene	.42-.58	1.3-1.9	—	—	—
Polystyrene	**.19*-.43**	0.72-1.7	.57-.61	.65-.90	.75-.90
Vinyl	.24-.43	0.10-2.4	.62-.92	.75-1	.85-1

[a]Cost of base molding compound in ¢/lb divided by molded specific volume in cu in./lb.

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Material	Ingot	Sheet[a]	Plate[b]
Primary(99-99.9%)	**.26***	—	—
13, 43, 214	**.26*-.32***	—	—
1100-F, 3003-F	—	.47-.57	.44
5052-F	—	.53	.47
6061-T6	—	.50	.47

[a]Thickness range 0.048-0.061 in., mill finish.
[b]Thickness range 0.250-3.0 in., mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	**.49***	**.51***	**.52***
Seamless Tubing	**.56***	**.56***	**.57***
Rod (not f.c.)	**.49***	**.51***	**.52***
Wire	**.49***	**.52***	**.53***

NICKEL

Form	"F"	"A"	Monel
Ingot	.76	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.38	1.20
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

LEAD

Common Grade	**.11***
Sheets[a]	**16.50***

[a]Rolls of 140 sq ft or more.

MAGNESIUM

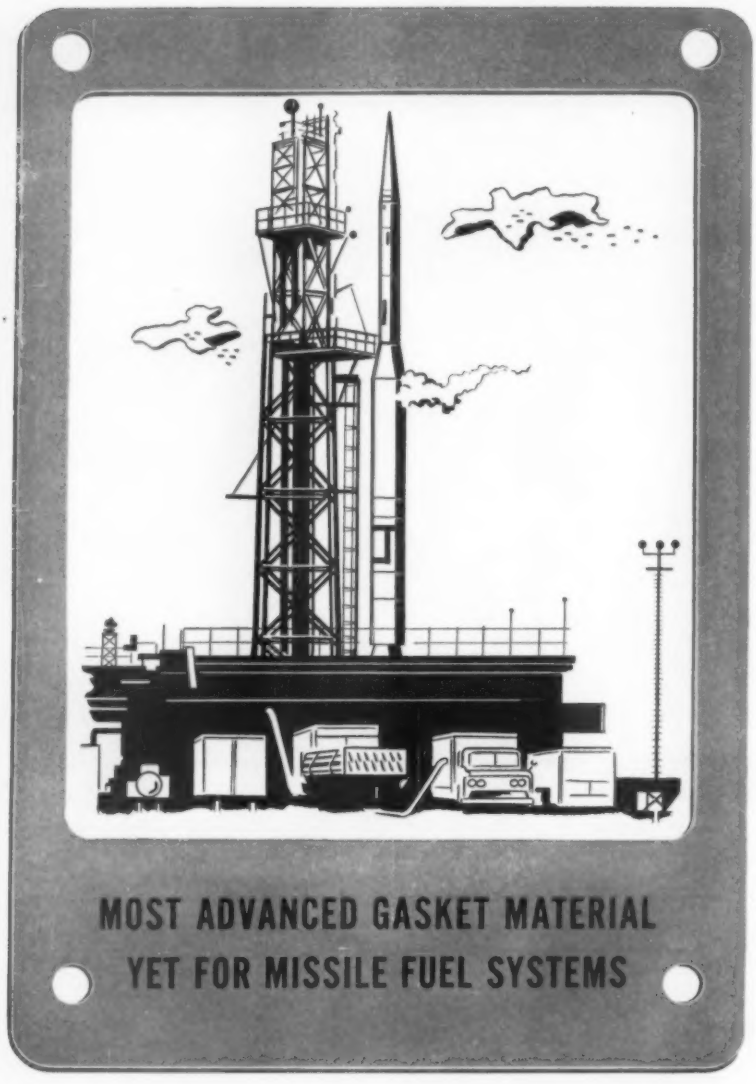
Material	Ingot	Sheet[a]	Plate[b]
Primary (98.8%)	.36-.37	—	—
AZ91B (die casting)	.37	—	—
AZ91C (sand casting)	.41	—	—
AZ31B (std grade)	—	.69-1.03	.68
AZ31B (spc grade)	—	.97-1.71	.93

[a]Thickness range 0.032-0.188 in.
[b]Thickness range 0.250-2.0 in.

COPPER

Ingot (elec)	**.29***
Sheet, Strip (hot rolled)	.52-.57
Seamless Tubing	**.55***
Rod, Drawn	**.52***
Wire	
Round	**.34***
Square, Rectangular	.42
Magnet	.44

◀ For more information, turn to Reader Service card, circle No. 419



MOST ADVANCED GASKET MATERIAL
YET FOR MISSILE FUEL SYSTEMS

R/M FLUOROBESTOS*—an asbestos felt impregnated with "Teflon,"† is fast becoming the accepted gasket material for missile fuel systems.

Approved by leading missile manufacturers for its compatibility with LOX and other exotic fuels, this new material combines "Teflon" and Pyrotex,® a carded asbestos felt based on extra-long spinning grade fiber.

In airborne and ground support applications, gaskets of Fluorobestos offer weight savings, high resistance to acids and solvents, and less deformation under load (as little as 0.1% under pressures of 2000 psi at temperatures to 500°F).

Fluorobestos is available in standard sheets of 40 x 40 in., in thicknesses from .015 to .125 in. Write for complete information and test samples.

*Registered trademark for R/M reinforced asbestos Teflon sheet.
†Registered trademark for Du Pont fluorocarbon resins.

R/M

PLASTIC PRODUCTS DIVISION
RAYBESTOS-MANHATTAN, INC.
Manheim, Pa.

BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2
HOUSTON 1 • LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3
PITTSBURGH 22 • SOUTH SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL

For more information, turn to Reader Service card, circle No. 339

PRICES & SUPPLY

TITANIUM

Sponge (99.3+%)	1.50-1.60
Bars, Rod	3.80-6.25
Plate	5.25-9.00
Sheet, Strip	6.75-15.50
Wire	5.55-9.50

ZINC

Prime Western	11.5*
Die Casting Alloys[a]	.17
Sheet	.28
Ribbon	.23
Plates	.22

[a]Alloys 2, 3, 5.

NONFERROUS POWDERS

Aluminum[a,b]	.39
Brass[a]	.33*-.50*
Cobalt	1.50
Copper (elec or red.)[a]	.44
Molybdenum (98%)	3.15-4.10
Nickel	.74*
Tantalum	30
Tungsten (C-red. 98.8%; H_2—red. 99+%)	3-4[c]
Zirconium	
Flash Grade	4
Electronics Grade	15

[a]Price for —100 mesh. [b]Freight allowed. [c]Delivered price.

OTHER NONFERROUS METALS

Cadmium (bars)	1.60
Columbium	36*-55*
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)[a]	.34-.36*
Palladium	$24-26/troy oz
Platinum	$82-85/troy oz
Silver	90-91¢/troy oz
Tantalum (sheet, rod)	55-60
Tin (straits)[b]	1.01*
Vanadium (90%)	3.45*
Zirconium (sheet, strip, bar)	11*-30

[a]Delivered price. [b]Spot.

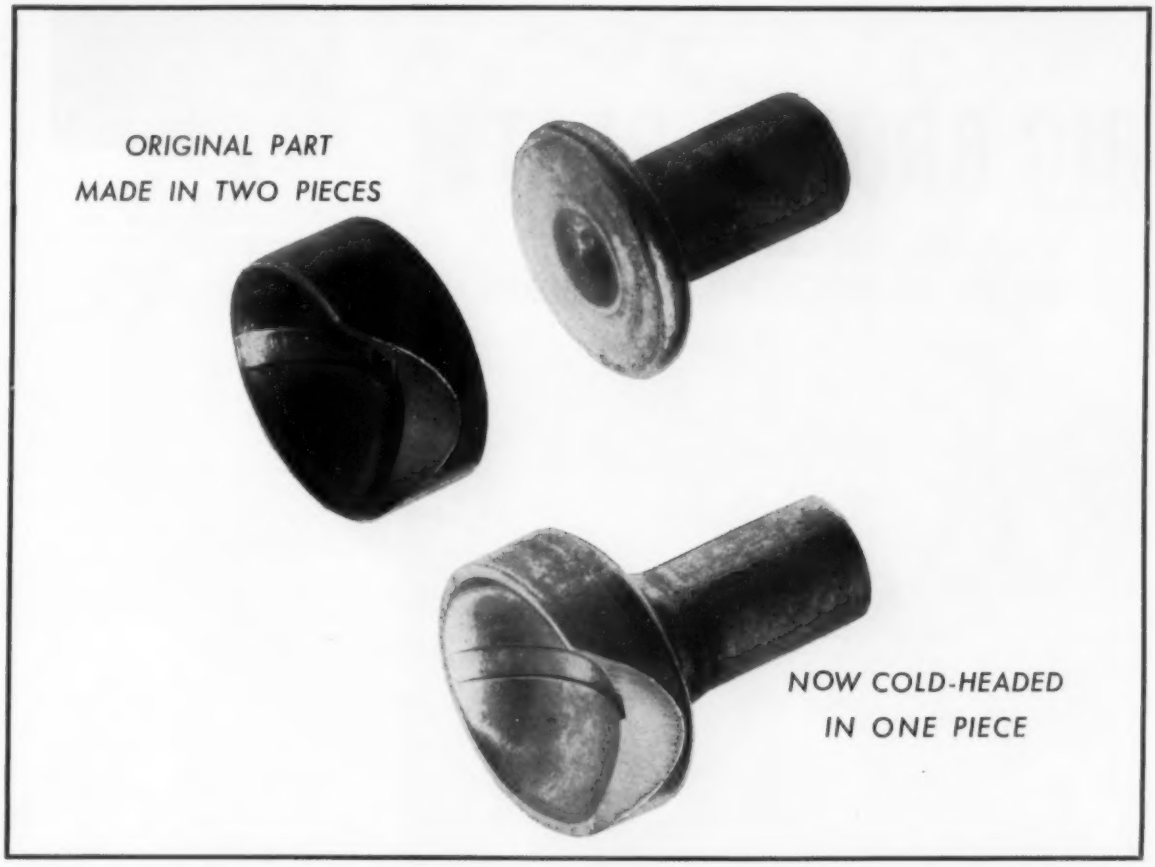
IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	82
Billets, Blooms, Slabs	
Carbon, Re-Rolling	80
Carbon, Forging	99.50
Alloy, Forging	119
Seamless Tube Rounds	122.50
Wire Rods	$6.40/cwt

(continued on p 144)



Cold-heading cuts costs—
replaces two parts with one!

The two-piece part, comprising a stud and a seat, has been replaced by a single part which is now cold-headed at considerable savings. It's used in the assembly of an automotive steering-rod relay system.

A special type of Bethlehem cold-heading wire was developed for this job. Costs are well under the previous method of manufacture. Cups have good surface finish and high strength.

This is a typical example of the small parts which are constantly under study by manufacturers searching for better materials, improved methods, and lower costs.

Look at these advantages of cold-heading

High-speed production . . . low scrap loss . . . economical stock . . . high strength . . . minimum of finishing operations.

Perhaps your product can be cold-headed

Heading-quality wire, custom-made for the job, has long been a Bethlehem specialty. Our metallurgical engineers will gladly work with you if you have a product that might be cold-headed. For any of your wire needs, call your nearby Bethlehem office, or write us at Bethlehem, Pa.

Steel
For strength . . . economy . . . versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
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BETHLEHEM STEEL

BETHLEHEM STEEL

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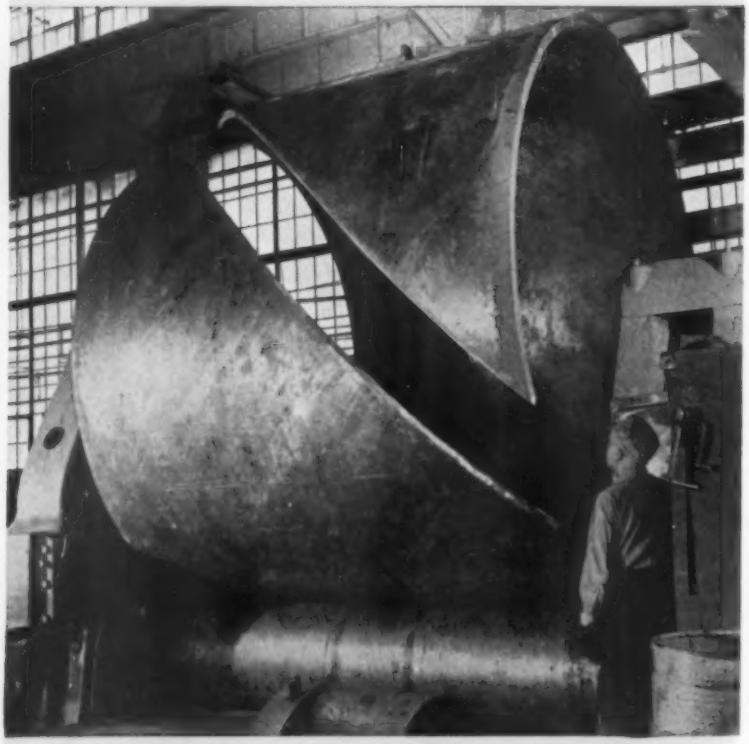
AMPCO®

BIG BRONZE PLATE!

**Varying dimensions—
up to 10,000 lbs. in weight**



Here's an idea of what you can get in

AMPCO® metal

A single Ampco metal plate can be big enough (½" x 192" x 360") to form a tank 16' high x 11'-6" diameter! Big enough (1" x 180" x 240") to form a tank 15' long x 5'3" diameter!

An Ampco metal tube sheet 2" thick can be rolled 10'-6" in diameter. One 3" thick can be 9'-0" in diameter.

What are *your* requirements for corrosion, abrasion, or mechanical service? Talk it over with your Ampco field engineer. Write for bulletin.

AMPCO metal

AMPCO METAL, INC.
Dept. 10C, Milwaukee 1, Wis.
West Coast Div.: Huntington Park, Calif.
Southwest Div.: Garland (Dallas County), Texas

For more information, turn to Reader Service card, circle No. 402

PRICES & SUPPLY

FINISHED STEEL (¢/lb)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.30	7.95	7.50
Sheet, HR	5.10	7.52	—
Sheet, CR	6.27	9.27	—
Strip, HR	5.10	7.57	8.40
Strip, CR	7.42	10.80	15.40
Bar, HR	5.67	8.30	6.72
Bar, CF	7.65	—	9.02

STAINLESS STEELS ($/lb)

Material	Forging Billets	H.R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.39-.50	.46-.50	.41-.46	.51-.57
321[a]	.49	.58	.55	.66
347[a]	.58	.67	.65	.79
Martensitic				
410[a]	.29	.35	.30	.40
416	.30	.36	.31	.48
403	.29	.35	.30	.40
420, 440	.36	.43	.40	.62
Ferritic				
405, 430, 430F[a]	.31	.36-.37	.31-.33	.41*-.52
442	.33	.40	.37	.56
431	.39	.46	.41	.56
446	.41	.48	.43	.70
High Mn				
202[a]	.38	.45	.40	.49
Extra Low C				
304L	.47*	.55*	.54	.63
316L	.72	.84	.80	.89
Precip Hard.				
17-7PH	.69	.76	.85	.90
PH 15-7 Mo	.89	.97	1.11	1.16

[a]Ingot price approx 60% of billet price.

FERROUS POWDERS ($/lb)[a]

Sponge Iron	.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.33
Stainless Steel	
304	.89
316	1.07

[a]Price for −100 mesh.

IRON ($/gross ton)

Pig	66-67

(continued on p 146)

Colonials'

"SILICOL"® SILICONE RUBBER

can improve your product and simplify fabrication problems

★ ***ANY MOLDED SHAPE***

★ ***ANY COMPOUND FORMULATION***

Colonial Rubber has a long record of achievement in using the unique properties of silicone rubber to meet "tough service" applications in all types of manufacturing. Particularly outstanding are the many special compounds our chemists have formulated to meet unusually rigid performance requirements in aircraft and missile applications.

In addition to the comprehensive industrial rubber technology we offer to help manufacturers solve rubber compounding problems. Colonial has large, modern and complete plant facilities to assure lower cost rubber molding and fabricating. We are *known* for our ability to meet manufacturer's "emergency" delivery requirements on priority projects.

Save time on your programs by sending prints and pertinent data on your *first* inquiry. We will promptly return an analysis and recommendations, together with illustrated information giving you complete details on our organization and its ability to serve you efficiently and economically.

1718-A

COLONIAL RUBBER CO.

706 Oakwood St. AXminster 6-9611

RAVENNA, OHIO

For more information, turn to Reader Service card, circle No. 409

Are Small Precision Metal Parts Disturbing Your Sleep?

The manufacture of small precision metal parts—in large volume—can sometimes take on the aspects of a bad dream. The problems are frequently numerous and complex. Their solution calls for specialized experience.

Torrington is the leading specialist in this field. We have the skill, engineering experience and manufacturing facilities to produce—at high speed and economical cost—a tremendous variety of small metal parts of exceptional precision and uniformity.

If you have such parts to be manufactured in large quantities, why not let Torrington solve your entire problem? Write us for complete information—or better yet, send us a blueprint, and we'll be prompt in making our recommendation.

progress through precision **SPECIAL METAL PARTS**

THE TORRINGTON COMPANY Torrington, Connecticut

For more information, turn to Reader Service card, circle No. 385

PRICES & SUPPLY

CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	29	32	34
304L	34	37	40
316L	47	51	56
321	35	38	41
347	41	45	49
430	23	26	28
Inconel	60*	70*	81*
Nickel	52*	62*	73*
Monel	54*	64*	74*

[a]Prices given for three cladding thicknesses.

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.40-10.65
Electrolytic (0.25-0.75 lb)	9.10-9.75
Black Plate	8.20

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.5
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified Alkyd	1.5	1.5	1.5
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.0
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.5
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.5
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.5
Vinyl	1.0	2.0	2.5
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a]Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.
[b]Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

FOR SHEER, SHEAR STRENGTH

Hydraulic Pressure tests on Bridgeport Brass Company's patented cladding system show perfect no-leak bonds over 3000 psi.

...*Bridgeport Brass Uses EASY-FLO 45 to Bond Their Clad Metals*

The "thick and thin" of cladding—from .010 to 2¾" in a combination of ferrous and non ferrous metals—calls for a bonding agent that will hold under the most severe forming and service operations. The answer, in every respect, is Handy and Harman's silver brazing alloy, EASY-FLO 45.

The uses to which these clad metals are put range from the kitchen to power plants, refineries, chemical and food-processing installations. Famous Bridgeport Copperware, used by housewives throughout the country, is made from a triple-clad metal consisting of a sandwich of two sheets of .010 stainless steel bonded to both sides of a sheet of .025 copper. The metals are joined in Bridgeport's patented process at *finish gauge*. So strong is the bond that no difficulty is encountered in the forming operations which follow.

Tube sheets, though their uses are far from "domestic," require the same "bondability." Tests at Bridgeport show that shear strength exceeds 20,000 psi. And this involves the cladding of carbon steel to as many different metals as stainless, brass, Monel and copper.

The primary need here, of course, is strength. EASY-FLO 45 has other attributes that are more than welcome under *any* metals-joining conditions: thermal and electrical conductivity, gas- and liquid-tightness, ductility, ease of application and economy are some more that we'd like you to know more about. We are ready indeed to further acquaint you with the significant benefits of silver alloy brazing by sending you our Bulletin 20, which is a clear and comprehensive introduction to one of the simplest, *saving* metals-joining methods in existence. Handy & Harman, 82 Fulton Street, New York City 38.

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Who's to Blame for the Parthenon Mess?

As early as 447 B.C. the young architect, Anacreon, went to see the Parthenon builder, Ictinus, to persuade him to use Washington Steel's ColorRold Stainless Steel as the curtain wall material. But Ictinus, a status quo seeker, obstinately refused.

No wonder the Parthenon now lies in ruins!
As Anacreon said to Ictinus, "Sure, your type of construction may last two or three thousand years, but if you want to build a *permanent* structure you should use Stainless Steel."

There is no substitute for stainless steel whether you are building a skyscraper, a space vehicle or a kitchen sink. Washington Steel's ColorRold Stainless enables you to enhance the beauty of your quality product. *It's a better product if it's made of stainless steel.*

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(cont'd from p 118)

rials to come out of this development are Min-K and microcrystalline micro fibers.

Min-K insulations are unique because their thermal conductivity is below that of still air (Fig 2). They consist of radiation "blocking" agents and fibers, and silicate materials whose pores are smaller than the mean free path of air molecules. Thus, they are particularly advantageous where insulating space is at a premium.

Actually, these insulations are a family of products which are tailor-made for specific applications; the lower the temperature range the lower their conductivity. One form of the material will operate continuously at hot face temperatures of 2000 F. At high temperatures the radiation component of heat transfer—which varies as the cube of absolute temperature—becomes the predominant factor. The flatness of the conductivity curve of any material indicates its advantage at high temperatures.

Although Min-K is considered a radiation-type insulation (under steady-state conditions), it has an unusually low diffusivity of 0.003 to 0.004 sq ft per hr, as compared to 0.005 to 0.008 for asbestos-reinforced plastic. Consequently, the material is extremely advantageous for certain low heat flux applications where heat blockage is of prime concern because of its appreciable saving of weight (Min-K weighs 20 pcf vs 110 pcf for asbestos-reinforced plastic).

Refractory materials

Refractory materials are useful for radiation systems because of their high heat resistance and their structural qualities which permit them to be used as external surfaces without additional protection from erosion. However, they are limited by their high weight and relatively high thermal conductivity (see Table 5).

Despite their high weight, insulating firebricks could possibly be used for aerospace applications. A comparison of their thermal conductivities with previously discussed materials is shown in Fig 2. Although the thermal conductivity times density values of firebrick are higher than those of fibrous and low density materials, they are considerably lower than those of sprayed reinforced ceramics.

Ceramic foams are like insulating firebricks in that they do not require additional protective covering. Temperature limit of the foams ranges from 1600 to 2000 F, as contrasted to up to 3000 F for insulating bricks. The foams are generally stronger than the bricks; however, although they do not crumble, they are easily abraded. As Fig 2 shows, the thermal conductivity times density factor of a typical ceramic foam is lower

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Battelle Memorial Institute Project Rand. Rpt. RA 15080, Apr '48.

Bidwell, C. C. and Hogan, C. L., *Jnl. Applied Physics*, 18, pp 776-9, '47.

Kelley, K. K., U. S. Bureau of Mines Bulletin 476, '49.

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WADC TR 57-488, J. I. Lang, Armour Research Foundation, July '57.

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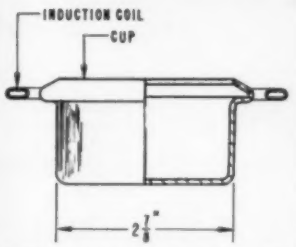

Flanges of cups made from type 321 stainless steel are selectively annealed by induction heating prior to further forming. Flanges are heated to 2000° F and water quenched. Single-turn coil restricts heating to the flange area.

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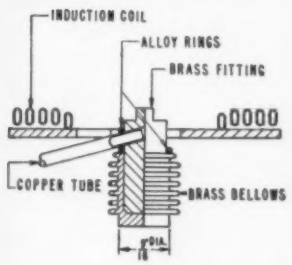

Brass bellows and copper tube are simultaneously silver-alloy brazed to a brass fitting by induction heating. Plate-type induction coil produces proper temperature at each joint.

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ENGINEERING & DESIGN

than that of insulating brick under certain conditions. However, this is not true at high temperatures.

Composite insulations

In many applications the choice of materials is not always well defined. In such cases, a combination of materials may produce the best system in terms of both thermal and weight factors. In other cases, a combination of *systems* may give the best service.

The potential benefit of combining the efficient insulating properties of one material with the high heat absorption or good ablative properties of reinforced plastics is readily apparent. This has been done with Min-K which is available in sandwich combinations with plastic and/or metal facings of various types and thicknesses. An excellent example of how insulations can be successfully combined is described in the case history on p 114.

Plastics Worm Screws Feed Bottle Fillers

Laminated phenolic plastics are replacing steel and cast iron in helical screws that feed bottles and cans into automatic filling machines. These intake screws also keep the containers from bunching during air cleaning, filling, capping, labelling, or sorting.

The principal advantages of the conversion, according to Pneumatic Scale Corp. Ltd., Quincy, Mass., are noise reduction and substantially longer life for the part. In addition to the economies resulting from the plastic's durability, considerable savings result from reduced fabricating and patternmaking costs.

Noise, wear are metal drawbacks

The major problem with metal helixes was the high noise level resulting from individual containers hitting the guiding edges of the feed screw. Abrasion of the screw and scoring of the container were also objectionable.

In deciding on the plastics, Pneu-

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See RULON designers guide book — Bulletin #9572 in Sweet's Product Design File, or send details for recommendations. DIXON CORPORATION, 102 BURNSIDE ST., BRISTOL, RHODE ISLAND.

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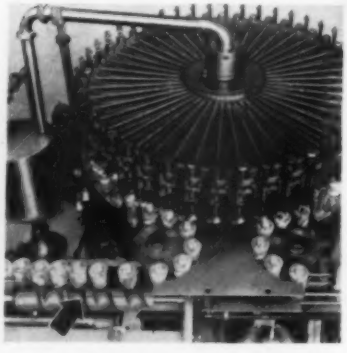
ENGINEERING & DESIGN

matic Scale Corp. tested and discarded both iron castings and steel forms. Split-molded iron castings required expensive hand filling and polishing to achieve uniformity. Steel screws were also too costly because they had to be chromium plated to resist wear against glass.

The desired durability, abrasion resistance, machinability and economy were found in phenolic laminates. One of the materials used is a linen-based Micarta laminate made by Westinghouse.



***Helical intake screw** made of phenolic laminate (arrow) spaces metal detergent cans entering a 45-head filling machine.*

Iron Brackets Carry Cables Beneath Bridge

Ductile iron brackets have successfully solved three difficult design problems encountered in laying high-voltage cable on the Queensborough Bridge between Manhattan and Queens in New York City.

The three restrictions in using the old bridge were: vibration set up by heavy traffic; the restricted space available for the cables; and the virtual impossibility of maintenance once the cables were installed.

Six conduits about 8.5 in. in dia cross the 3700-ft run on the north and south sides of the bridge. Each conduit, with cable, weighs about 300 lb per ft.

Ductile iron was used by Crompton and Knowles, Corp., Worcester, Mass. for the brackets because it combines the corrosion resistance of cast iron with the strength of steel.

Each bracket supports six con-

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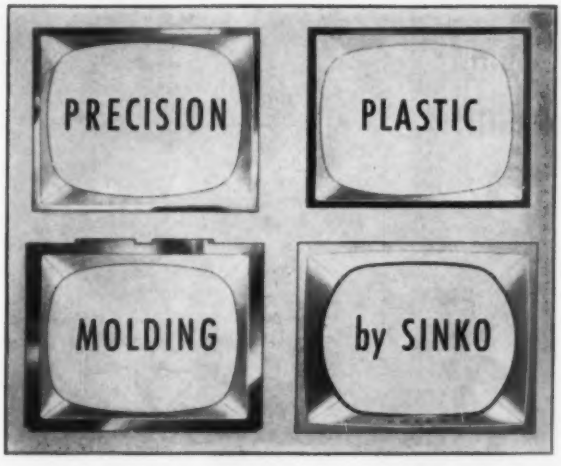

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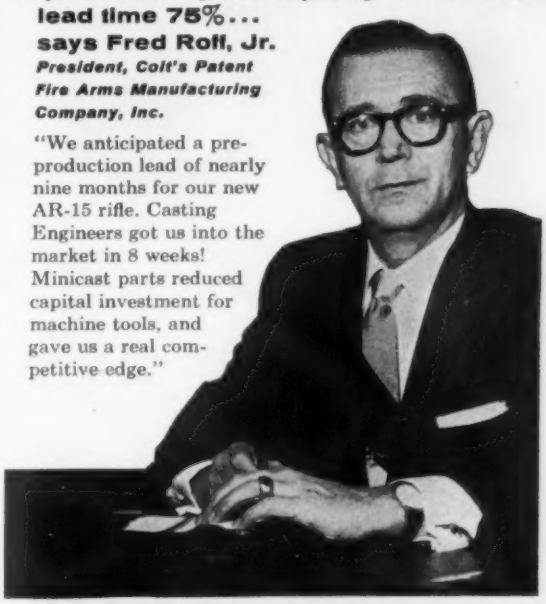

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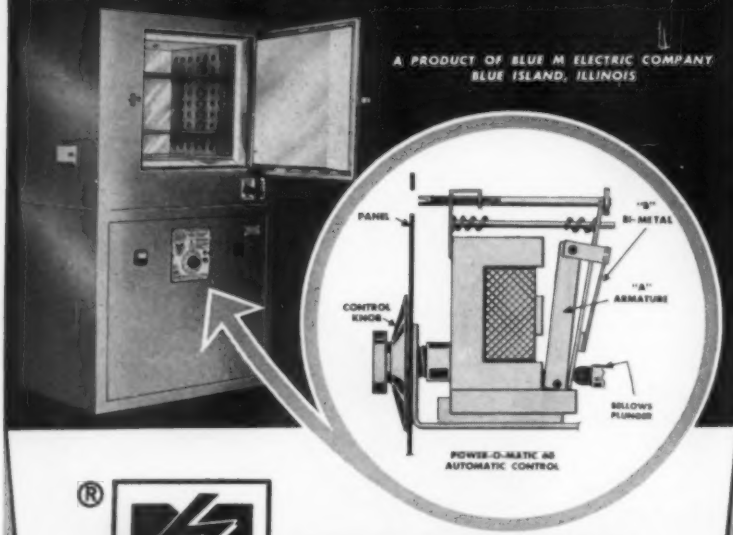

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duits arranged in two levels and weighs 275 lb. The brackets are spaced every 12 to 25 ft along the bridge.

Plastics cladding used

The brackets consist of a frame supporting three rollers that allow for expansion and contraction of the cable. The rollers are coated with reinforced polyester resin to insulate the pipes from the bridge structure and any possible stray currents coming from other services using the bridge.

The pipes themselves are coated with an epoxy resin reinforced with glass mesh to prevent weathering. Welding was not required in the installation. It was a simple plotting operation with the brackets themselves serving as templates for drilling bore holes.

Phosphate Lubricants for Hot Metal Forming

Increased tool life and reduced tool removal pressures in the piercing of seamless tubing have been achieved with the use of phosphate lubricant systems developed in West Germany.

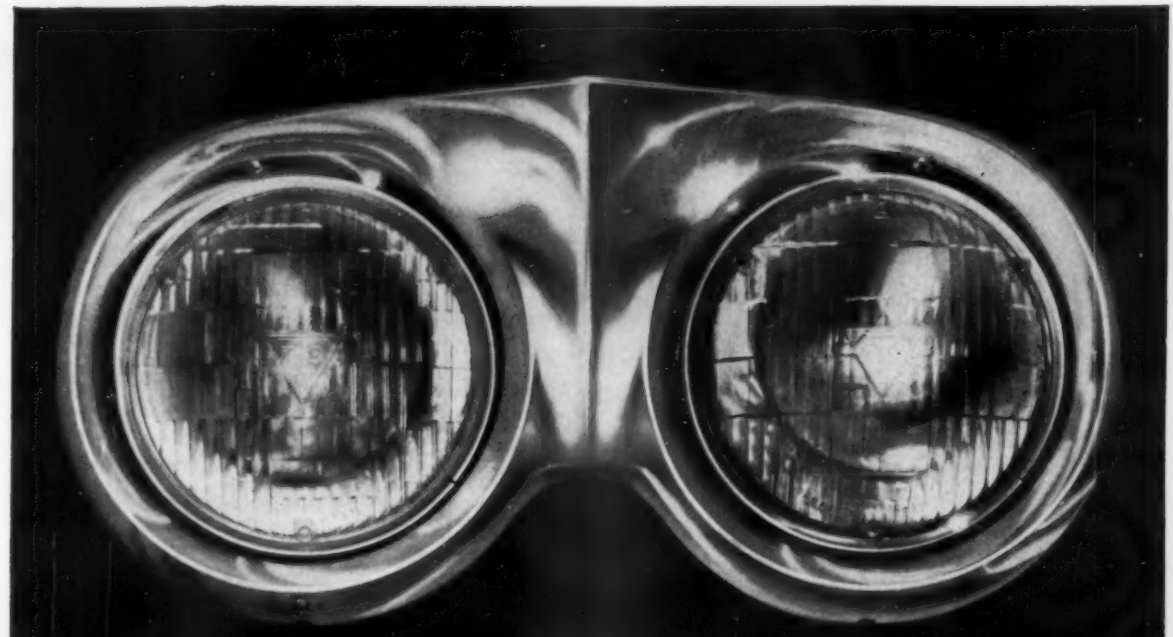
In a typical operation, mandrel life was increased from 5 to 50 billets and the pressure required to remove the mandrel was cut from nearly 3000 psi to 200-900 psi.

These phosphate lubricant systems were recently described by G. Graue and I. W. Luckerath of Phoenix-Rheinrohr AG as basically mixtures of sodium, potassium and phosphorus pentoxide. The lubricants are recommended for use at temperatures from 1100 to 2200 F.

Lubricant is water soluble

The lubricants are said to provide a water soluble melt which softens at high temperature, with the viscosity of the melt dropping evenly and steadily with increasing heat.

The lubricant and its variations, which may contain additions of borax, alkali halides, sulfates or certain metal phosphates, can be used as powders, but solutions are easier to apply. After the water evaporates at high temperatures, a wetting adhesive lubricant film forms on both the work and tool. The film retains its load-carrying capacity



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under extreme pressures because it forms a phosphate boundary layer on the metal surfaces.

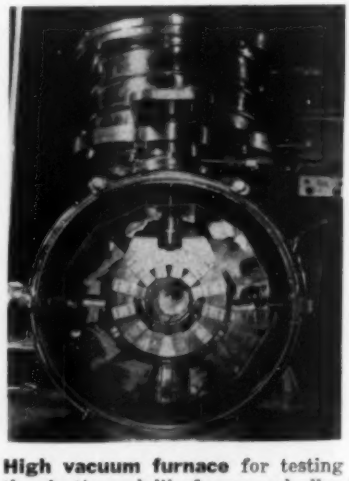
One of the lubricants has recently been introduced in the United States and Canada by Alpha-Molykote Corp., Stamford, Conn. under the tradename "Phosphatherm RN."

Phenolic Glove Ports

Molded phenolic has solved a cost problem in the design of glove ports used to handle radioactive plutonium in sealed enclosures.

According to Hooker Chemical Corp., the problem lay in selecting an economical material that was: 1) resistant to corrosion and fire; 2) structurally sound; 3) leakproof; and 4) easily installed into a variety of materials of varying thicknesses. In addition, the ports had to have a smooth finish and a short contour to allow for positive glass sealing and safe glove changing.

Originally, parts were machined from solid or welded metal stock, or rolled and formed from 20-gage



High vacuum furnace for testing the elastic modulii of pure and alloy refractory metals at temperatures up to 4000 F and at pressures as low as 0.2 μ Hg. Tantalum heating elements radiating from the central test chamber are framed by molybdenum radiation shields. The metals to be tested are intended for use in jet engines and missiles.

Steel

Tool Steel Topics

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

Another report on Air-4 tool steel

Blanking and embossing this automotive part, from coiled steel of .125 in. thickness and doing it at substantial speed, is all in a day's work for Bethlehem Air-4 tool steel . . . at Melrath Metal Stamping Corp., Red Hill, Pa. Tool engineers at this plant have several good reasons for giving a good report on Air-4: they like the ease with which it can be machined . . . its simple heat-treatment, and above all, they admire its wear-resistance. Hardened to Rockwell C-60, the die undergoes slight redressing every 100,000 strokes of the press.

HARDENS AT LOW TEMPERATURE

Air-4 is a free-machining, medium-alloy tool steel which hardens in air—at about 1550 F. It has excellent free-machining characteristics because of a lead addition. It also has excellent wear-resistance and high toughness, and is deep-hardening to assure long tool life.

Air-4 is a versatile tool steel. Why not place an order right now for a trial bar, and use it in an experimental run? Your Bethlehem tool steel distributor can give you prompt delivery.

Bethlehem Tool Steel Engineer Says:

Always Heat-Treat the Tool Instead of the Thermocouple

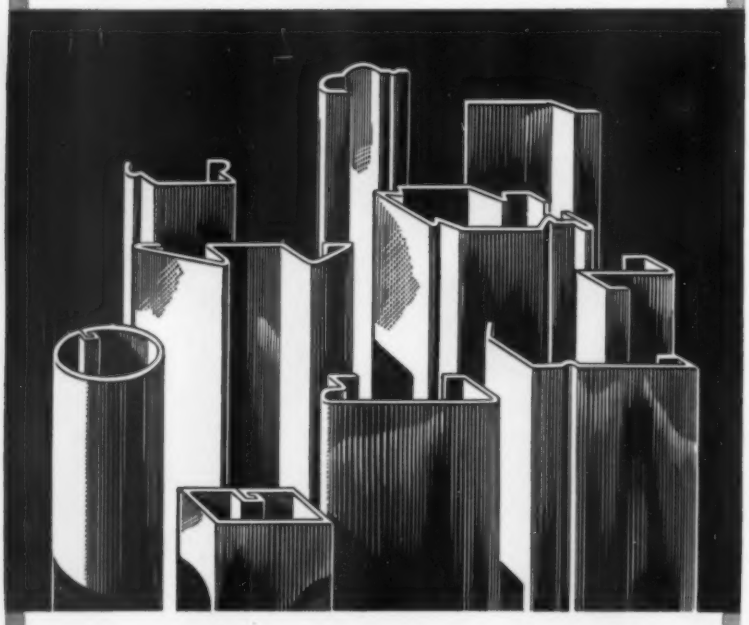
Many tool failures can be attributed to the use of improper temperatures during heat-treatment. In many instances, although the thermocouple chart may have indicated proper heat-treatment temperatures, the microstructure of the tool shows that the recorded temperatures were not attained by the tool. This is called "heat-treating the thermocouple, instead of the tool."

It is easy to see why such errors occur, for the thermocouple indicates the temperature at the location of its tip only. Most furnaces have some non-uniformity of temperature. For example, locations near the source of heat are hotter than remote locations. And the bottom tends to be colder than the top. An operator who is on the ball will survey his furnaces to determine what temperature differences are present. This will assist him in selecting the location which will provide the most accurate indication of the temperature of tools heated in each furnace. It will often indicate that more than one thermocouple is needed.

Where a temperature survey is not feasible, the tip of the thermocouple should be placed as near the tools as possible. But avoid locations near the floor, sides, roof, or near the source of heat. Although the thermocouple is accurate, and highly useful, it's by no means foolproof.

For more information, turn to Reader Service card, circle No. 377

SALES APPEAL



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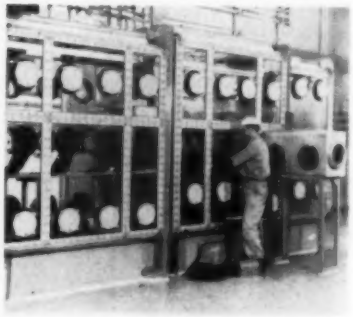
For more information, turn to Reader Service card, circle No. 338

stainless steel. When larger quantities were required, aluminum castings were specified. Although the aluminum ports satisfied design requirements, costs were considered too high. According to Hooker, compression molded medium impact phenolic solved the problem.

Phenolic glove port rings and flanges are bolted to inside . . .



. . . of glass-walled chamber.

Inexpensive Meter for Light Transmittance

The light transmission characteristics of plastics sheets for lighting fixture covers can be easily and adequately measured with an inexpensive light meter developed by the Materials Laboratory of Chicago Molded Products Corp.

Wide band source, detector

The unit, designed by C. L. Andrews III, and D. E. Pittan, provides an economical substitute for expensive calibration equipment that would not be used continuously. The unit, called "Campco-Lite," costs less than $100.

A photovoltaic cell detector and photographic photoflood light source

(Advertisement)

the LEAD newsletter

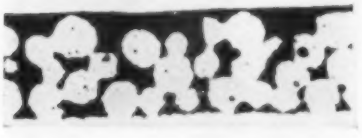
Vol. 2 No. 6

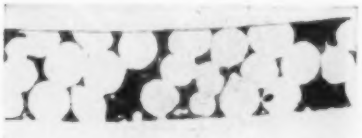
Lubricity is a property of lead that is somewhat unusual among metals – a property that results in a variety of uses. The most obvious is in bearing metals. In this instance it is sometimes employed as an alloy to make bronze, tin-base and lead-base babbitts. Or, through powder metallurgy, other combinations like high-lead copper for bearings are produced. Mixtures of lead and Teflon and coatings of lead oxide are newer developments in this field.

DU Oilless Bearings

These oilless bearings are made from lead and T.F.E. fluorocarbon (Teflon) powders impregnated into a sintered bronze matrix, with a steel backing to provide strength. They withstand a wide range of tough operating conditions, and provide long service life for thrust bearings, slides and general bearings. A more recent use is in helicopter rotor-shaft bearings, where high performance and minimum maintenance are required.

The coefficient of friction range with DU bearings is similar to that of conventional oil lubricated bearings, varying from 0.04 at high loads and low speeds to around 0.16 at fractional loads





Photomicrographs of DU before (above) and after "bedding in"

and high speeds with operation over a temperature range of –450°F. to 536°F. They have given trouble-free service even when exposed to abrasive cement, concrete mix and other dirt-laden atmospheres.

Lead Greases and Soaps

Industry in a search for more efficient greases found that lead in the form of a fine powder, intimately mixed with grease, markedly improved the latter's lubricating properties under the most severe operating conditions. In use, the leaded grease acts as a vehicle to carry particles of lead powder to gear or wearing surfaces where, under pressure, the lead coalesces and forms a uniform layer or film of lead. Extremely tenacious, this lead lining fills score marks, pitted or worn surfaces and thus, in effect renews them.

Another advancement in the manufacture of grease has been the development and utilization of lead soaps, using the lead salts of fatty acids. These include lead naphthenate, lead linoleate, lead oleate, lead recinoleate and others. Lead soaps do not change in viscosity during storage and do not separate or hydrolize in the presence of moisture. This prevents precipitation of the saponifying compound, and perpetuates the lubricating properties.

Lead Bearings in Rocket Flight

Rocket propulsion and supersonic aircraft pose a pressing problem for materials scientists need for high-temperature lubricating materials. Researchers at the NASA Lewis Research Center, Cleveland, have developed bearing systems for high speeds and high temperatures which will never require lubrication. Lead monoxide is "fired on" the bearing surfaces. Bonded lead monoxide coatings have better life and a lower coefficient of friction at high temperatures than such standbys as molybdenum disulphide. The reason: NASA's coating normally lubricates best under conditions which produce high surface temperatures. At sliding velocities of 2,400 to 10,000 ft. per min. (highest speed studied) the coefficient of friction was 0.05 to 0.08 for all test temperatures. High speeds, loads, and temperatures tend to form a viscous molten film. Sliding can then take place by plastic or viscous shear rather than shear along the crystal planes. Found to be best when its operating temperature is close to 1000°F. – though designed to operate in the 600 to 1200°F. range – data show that both bearing life expectancy and friction coefficient for cool operation are good enough to recommend it even when it must be started or cycled through room temperature. Lead monoxide and other formulations have been successfully applied to stainless steel and Inconel X. They can be applied as a dry powder or sprayed on as a watery slurry and fired at 1650 to 1800°F.

Miles of Lead-Lubricity

Under a treaty with Canada, the U.S. is building the $720 million Niagara Power Project – the largest hydroelectric development ever undertaken in the Free World. Lead, uniquely employed in sheet form, gaskets the more than 16½ miles of joints between the base and vertical members of two parallel concrete conduits. As a result, sheet lead serves as a lubricant during any wall movements due to stress induced by ground movement, contraction and expansion, while it also acts as a water seal for the joint.

Although other materials were considered, lead's lubricity was the deciding factor. If the massive wall blocks were not free to adjust their position, tremendous thermal and ground forces might buckle or shatter them. The ability of lead to carry heavy loads, its low cost, and the ease with which it is cut and worked are other factors that contributed to its selection. Lead is used in similar applications in bridges and other heavy construction, as a bearing plate and lubricant between supporting structural members.

For information or technical assistance on new lead developments and applications – and how they can relate to your products – see Sweet's (Design Edition) Catalog, or write to: Lead Industries Association, 292 Madison Avenue, New York 17, N. Y. 2633

LOOK AHEAD WITH LEAD

For more information, turn to Reader Service card, circle No. 360

W-2

CHROMALLIZING STOPS HEAT COLD

up to 4100°F

The Problem: To create a thermocouple housing that will endure extremely high temperatures without damage to the housing.

The solution: A CHROMALLIZED molybdenum thermocouple housing. This housing withstands temperatures up to 4100°F. Other applications are structural parts for re-entry vehicles, high temperature testing grips, and ramjet engine components.

What is Chromallizing?
A proven process for diffusing chromium and other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake. the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

CHROMALLIZING processes are also being used to protect superalloys for jet engine parts and to protect ordinary steel against wear, oxidation and corrosion.

WRITE FOR ILLUSTRATED BULLETIN MC

Chromalloy corporation

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SINTERCAST DIVISION, YONKERS, N. Y. Machinable carbides & nuclear materials.

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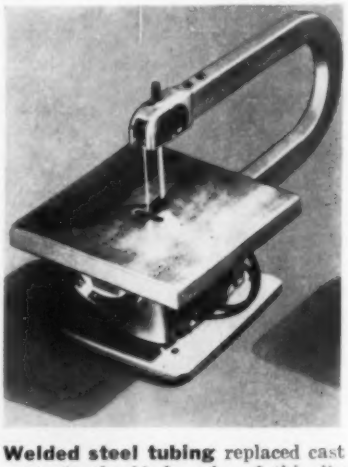
are used in the novel design. This system was preferred to a photoelectric cell and an incandescent lamp because the lamp provides insufficient violet and ultraviolet light to calibrate fluorescent lamps, and the photoelectric cell is sensitive to a narrower band of the spectrum than the photovoltaic cell.

The instrument consists of a vertical housing with the light source mounted in the top and the detector at the bottom. The inside of the case is painted dull black to minimize reflectance. An intermediate bulkhead incorporates a calibrated opening that helps columnize the light to give a more uniform distribution on the detector. The cell and the specimen holder immediately above it can be raised and lowered to zero the detector before measuring a specimen.

Three-step operation

Specimen calibration is done in three steps: 1) the detector platform is positioned at the zero meter reading, 2) the specimen is put in



Welded steel tubing replaced cast parts in the blade yoke of this jig saw. The rectangular tubing accepted the severe 180-deg bend without noticeable distortion or weakening. The result was a reduction in weight, and savings in time, materials, and assembly and shipping costs. Special-shaped tubing was preferred to round for its cleaner-lined, trimmer appearance.

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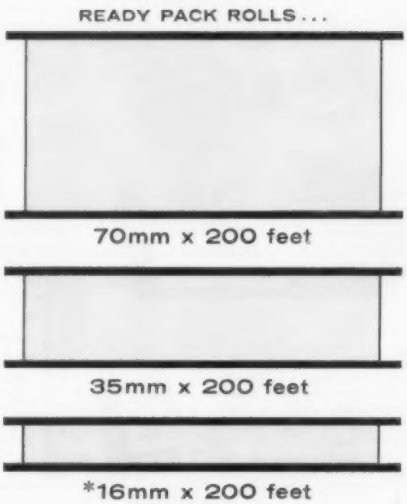
Kodak Industrial X-ray Film, Type AA and Type M in 16mm, 35mm and 70mm widths, 200-foot lengths

Here is America's preferred Industrial X-ray Film in a new convenient form—in 200-foot rolls, and in three widths. Ready Pack rolls are the answer for panoramic or moving slit methods of radiography of thin-wall vessels and pipe, honeycomb, circumferential welds, etc. Unroll the needed film, cut it off, seal the ends with opaque, pressure-sensitive tape. You are ready to inspect aluminum or magnesium alloys, thin steels or anything where lead screens are not required.

Ready Pack rolls are supplied on cardboard cores, 12 inches in diameter. The film is enclosed in a light-tight wrap-around sealed covering, without interleaving paper. It keeps clean and does away with darkroom loading. For processing, just separate the wrap along the sealed edge and remove the film.

For further information or to order a supply, contact your x-ray dealer or write us for a Kodak Technical Representative to call.



*For the present this size available only on a special order basis.

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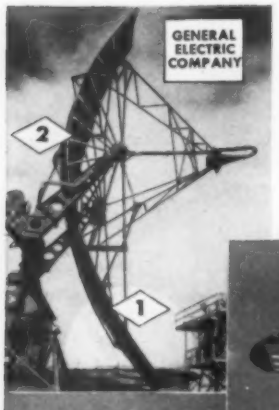
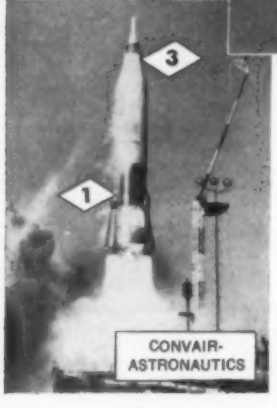
2 Iridite provides a highly protective non-porous paint base.

3 Iridite protects against corrosive storage conditions.





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ON ALUMINUM—needs only normal precleaning. Film withstands cold forming or bending. Easily heliarc welded. Unusually low electrical resistance. Clear, yellow or dye-colored finishes.

ON MAGNESIUM—short immersion, room temperature solution, no electrical equipment. Corrosion protection relatively unaffected by high drying temperatures. Applicable to all alloys. Low electrical resistance. Color ranges from light gray to dark brown.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Easily applied at room temperatures with short immersion, manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel; special equipment, exhaust systems or highly trained personnel not required.

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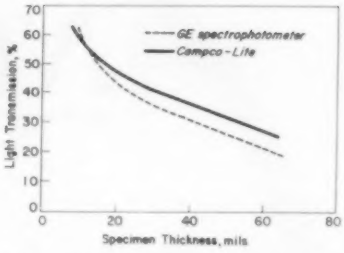


***Light transmission** readings made with the Campco-Lite meter and a GE spectrophotometer.*

the holder and the reading is taken, 3) the specimen is removed and the meter rechecked to be sure it returns to zero.

The photoflood lamp has a useful life span of 4 hr, equivalent to about three months use. A timing counter is used to assure that the bulb would not be used too long.

Because this instrument is intended primarily for comparative tests, some of its determinations were checked with a spectrophotometer. As shown in the accompanying graph, the curve made by this meter varies from 2 to 6% from the spectrophotometeric determinations.

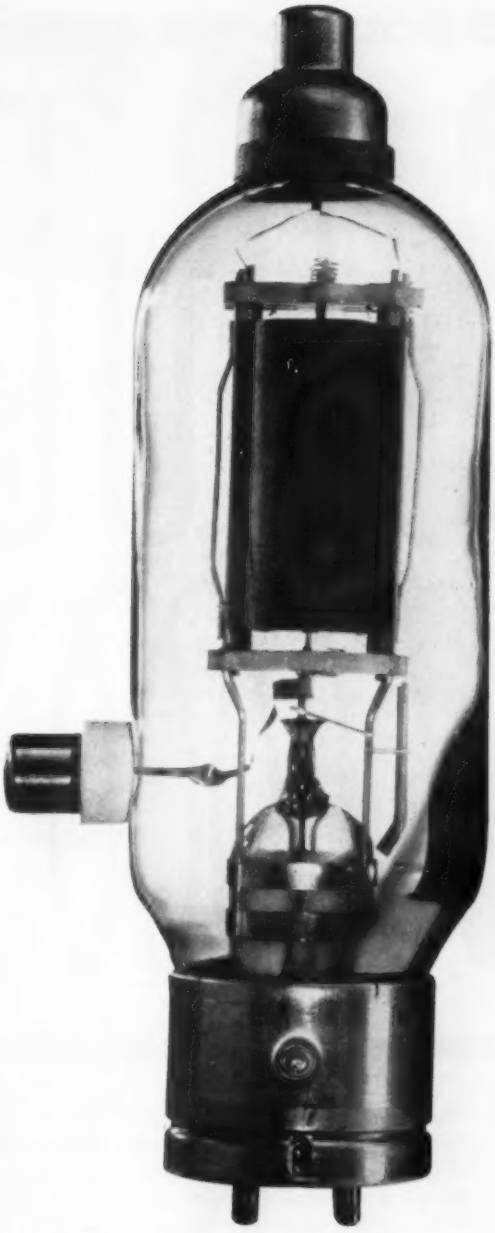
Acrylic Paint Protects Plastics Radomes

Coating large, glass-polyester radomes with an acrylic-type coating containing a small amount of titanium pigment met five simultaneous design requirements.

The requirements for the radomes were: 1) radar transparency, 2) heat reflectance, 3) adhesion to the plastic laminate, 4) weatherability, and 5) ease of application in the field. Originally, the domes were installed without any thought to protecting the outer surface from extensive weathering. In a relatively short time, it was found that the rate of deterioration was quite high and that protection would be necessary.

J. R. Lampman and G. F. Damon of General Electric Co., Heavy Military Electronics Dept., Materials and Processes Laboratory, Syracuse, N.Y. evaluated a number of coatings, including epoxy, acrylic, polyester and polyurethane types.

Ideas in Electronics from Norton



The electronics industry became a giant before it became a baby.

This outstanding growth has been largely due to the development of new materials — *refractory* materials with a great range of electrical properties. The prime source of these *idea refractories* is Norton Company.

For example, refractory fused alumina has high *constant* resistivity, to assure minimum leakage between elements in TV, radio and radar tubes. The same material is a recent innovation for transistor potting. Norton silicon carbide is an essential component in lightning arrestors and other non-linear resistors because of its variable voltage-current relationship. Silicon carbide is also finding new uses in microwave absorption, and as single crystals in high temperature rectifiers and transistors.

Fused magnesium oxide, used in most heating elements for electric ranges, has gained acceptance in such areas as advanced thermocouple design and infrared transmission.

Norton offers a wide choice of superrefined refractories, including oxides, borides, nitrides and carbides, and is ready to work with you in engineering materials to meet your needs. But above all, Norton offers ideas in every field in which refractory materials play a part. Write NORTON COMPANY, Refractories Division, 342 New Bond Street, Worcester, Massachusetts.

NORTON
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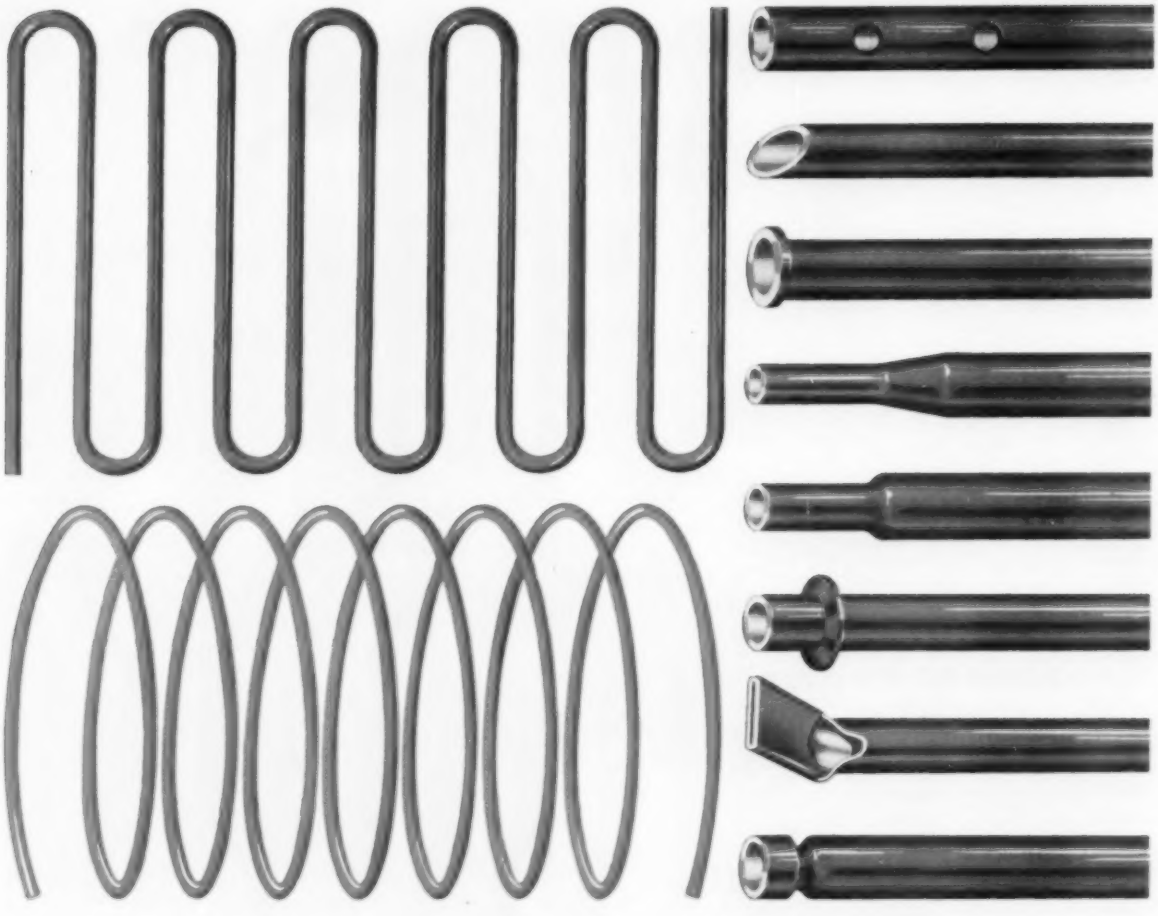
TURN TO ROCHESTER STEEL TUBING . . .



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(cont'd from p 119)

step and then by bake-curing. Coating thickness can be adjusted during dipping by altering solvent ratio. The DAP varnishes exhibit very low run-off or dripping after drying, as compared to other coatings which remain liquid or tend to drop during cure.

Good cures can be obtained by using peroxide catalysts and baking at 320 F for 15 min. Heat sensitive parts can be cured as low as 212 F if baking time is extended to 16 hr.

A typical composition

Coating formulators (FMC supplies the resins only) can supply varnishes based on both diallyl phthalate (Dapon 35) and diallyl isophthalate (Dapon M). The diallyl isophthalate varnish is particularly noted for its heat resistance. A typical varnish formulation (containing about 45% solids) consists of:

	Parts by Wt.
Diallyl isophthalate	100
Methyl isobutyl ketone	114
n-butyl acetate	6
t-butyl perbenzoate	5

Key No. 606

Aluminum Alloys for Auto Engines

As reported in previous issues of this magazine (M/DE, Nov '60, p 147 and Dec '60, p 9), the trend is toward aluminum in automobile piston engines.

And the promise of new and improved aluminum alloys for use in automotive engine block and cylinder head castings was held out recently by Yeshwant P. Telang of Ford Motor Co.'s Scientific Laboratory. He described such alloys—aluminum-21% silicon alloys with ultimate tensile strengths approaching 50,000 psi—at the 42nd national Metal Congress held last fall in Philadelphia.

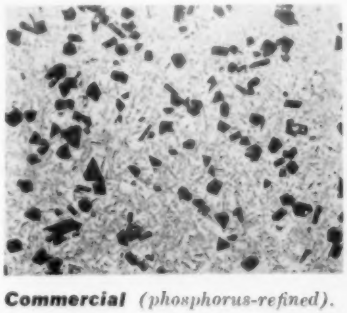
Telang says the new alloys have unprecedented mechanical properties, particularly for high silicon alloys. In fact, he says, properties of the alloys are higher than those of commercial automotive casting or heavy duty piston alloys currently in use. In addition to their high strength, the alloys have excellent hardness, impact and anti-friction properties, low density, and low thermal expansion coefficients.

Alloys of similar composition have been used for pistons in Europe for some time, Telang says, but their poor foundry characteristics, excessive variation in properties and poor machinability have caused them to be generally neglected in this country.

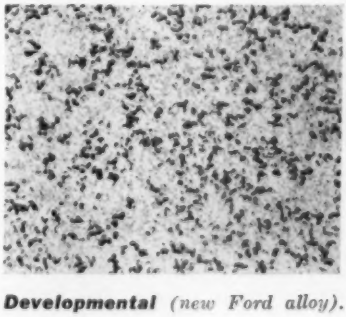
Fine microstructure

To achieve the superior properties mentioned by the Ford scientist, the alloys have been modified to produce

***Microstructure** of two aluminum-21% silicon alloys compared.*



***Commercial** (phosphorus-refined).*



***Developmental** (new Ford alloy).*

it's DELRIN*

You get metal-like properties in these new, plastic, prevailing-torque lock nuts: excellent strength, rigidity and dimensional stability.

Recommended for light metal assemblies, toys and similar fastening . . . they can save about half the cost of aluminum lock nuts.

Available in #10 and ¼" sizes, the RB&W open end acorn nuts have holding strength of 500-700 lbs in straight tension. Prevailing torque (a measure of its locking) is 8-10 in-lbs for the #10; and 12-15 in-lbs for the ¼". The nut forms its own thread. Pigmented gray is standard; other colors available in production quantities. Reusable. Send for samples.

Ask about other sizes and styles . . . and other parts custom molded from Delrin or other thermoplastics in production lots.

Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*DuPont trademark

RB&W
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a material with the finest possible microstructure (see accompanying photos). The alloys have the advantage of little or no loss in refinement during remelting, superheating or holding at elevated temperatures, according to Telang.

The alloys have been studied in sand cast, chill cast and permanent mold specimens with results that suggest their ultimate use for liner-free engine block castings.

Liquid Brightener for Zinc Plating Baths

A new liquid brightener for zinc plating baths has been introduced by Metal & Thermit Corp., Rahway, N. J. Identified as Brightener No. 25, the formulation is a free-flowing liquid that can be added directly to the plating bath without prior dilution.

The producer says the brightener is extremely useful for applying a uniformly bright zinc plate to low current density areas such as recesses and threads. The brightener is said to produce crystal clear deposits on case-hardened and hot rolled steels. It is suitable for use in barrel, hand, hoist and automatic plating operations. KEY NO. 609

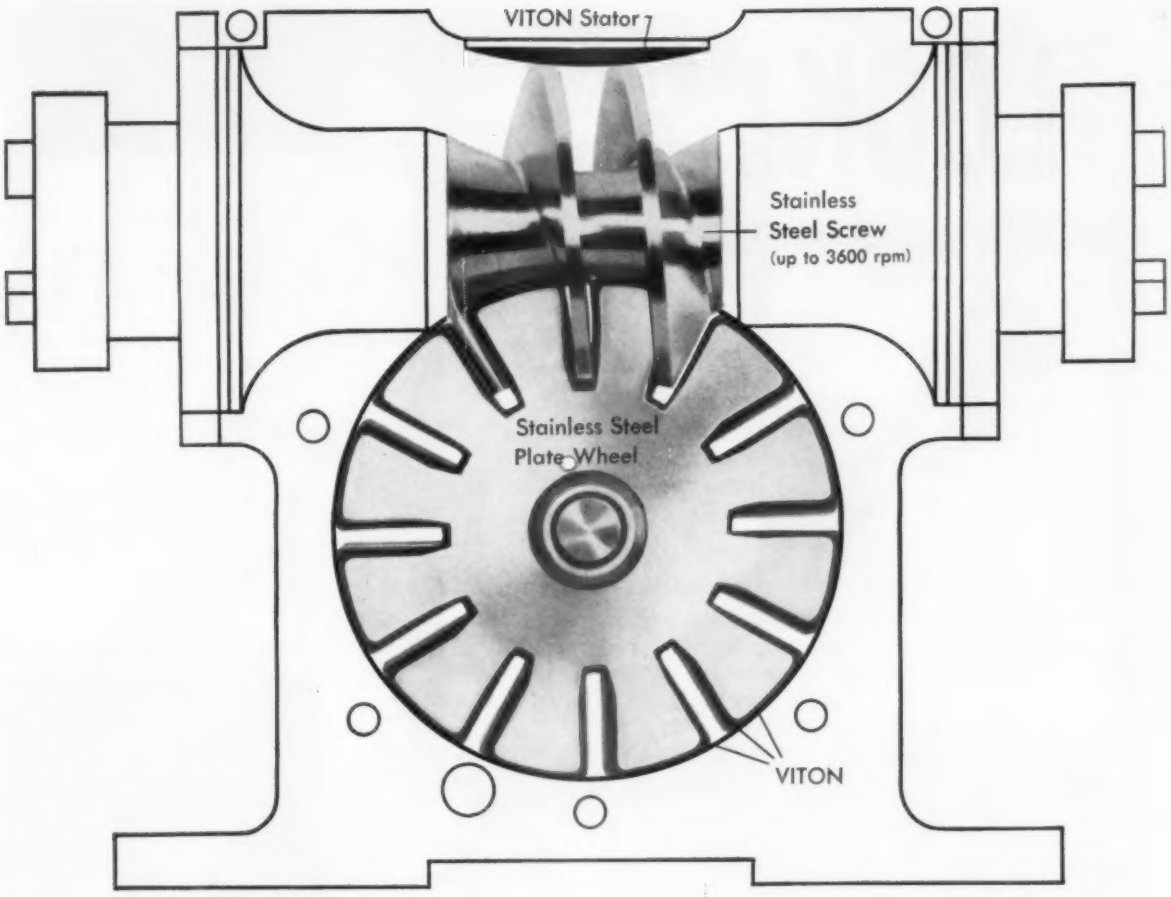
Gold, Cadmium, Cobalt, Iron Plating Processes

Several important electroplating processes were described at the annual meeting of the American Electroplaters' Society, held last summer in Los Angeles.

Gold can now be deposited by two additional electroplating processes: one produces heavy, nonporous deposits and can be used for protecting nuclear reactor components; the other produces thin, nonporous deposits and can be used to plate printed circuit elements. In addition, new sulfamate plating solutions have been used successfully to obtain cadmium, cobalt and iron electroplates.

1. Gold plating techniques

Heavy gold—The heavy gold plating process, developed by R. Seegmiller and J. K. Gore, Los Alamos Scientific Laboratory, University of



Durable VITON® helps solve corrosion, heat problems in design of new pulseless pump

A new twist on the 2000-year-old Archimedean screw principle has resulted in this unique positive-displacement pump, designed to handle highly viscous liquids and slurries containing abrasive and crystalline particles, without damage to crystals.

The key to the efficiency of this Goodyear* pump is the VITON-bonded plate wheel (see diagram). The slots are edged with durable VITON, which not only prevents galling, but exerts a squeegee wiping action that keeps "problem" liquids moving at full flow, without foaming or agitation.

Du Pont VITON was chosen for this application because of its exceptional resistance to corrosive chemicals and oil at high temperatures. No ordinary elastomer—natural or synthetic—could stand up to the corrosive attack while maintaining a positive seal at rotor speeds up to 3600 rpm.

Do you have a design problem that might be solved by VITON's unique combination of properties? To receive more detailed information, just mail the coupon below.

**A product of Goodyear Pumps, Inc., New York, N. Y.*

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Please send me your FREE booklet that contains technical data about VITON synthetic rubber.

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Firm_____

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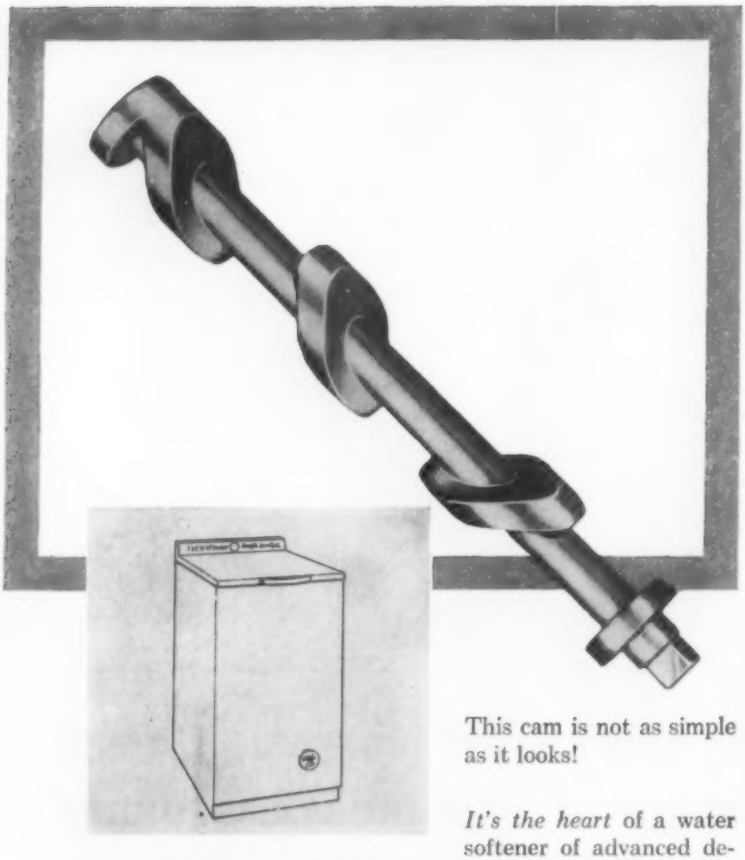
For more information, turn to Reader Service card, circle No. 370

LOOK what brass is doing now!



This cam is not as simple as it looks!

It's the heart of a water softener of advanced design for home use. The three projections around this Titan brass forging are a combination of six different angles from the center line of the piece. This design requires the skill of Titan die makers and forge pressmen. The closer tolerances of Titan forging in this reversing cam mechanism spell a big difference in the plumbing fixture where hand-in-glove fit is a must.

Use Titan forged brass parts to solve *your* design problems. Let us help design and quote on your component parts.

Call your nearest Titan Man for detailed data and a brass forging quote. Or send your sample and blueprint to Bellefonte, Pa., or Newark, Calif., for quick service.

Send for 32-page Titan Forging Handbook. Write us on your letterhead.

Established 1915

TITAN METAL MANUFACTURING COMPANY

DIVISION OF **CERRO CORPORATION**

Bellefonte, Pa. • Newark, Calif. • Offices & Agencies in Principal Cities

RODS • FORGINGS • DIE CASTINGS • WELDING RODS • WIRE

For more information, turn to Reader Service card, circle No. 447

What's new IN MATERIALS

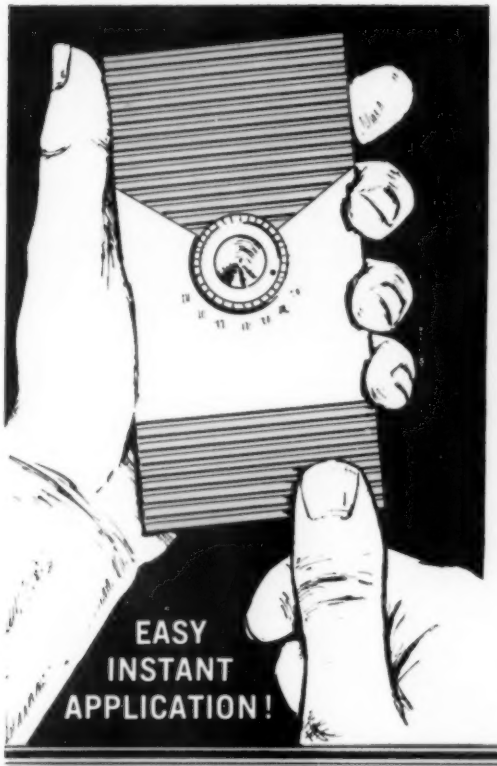
California, Los Alamos, N. M., uses a gold solution containing small amounts of sulfonated castor oil (turkey red oil) and relatively large amounts of free cyanide. Currents of 4 to 10 asf are used to make plates up to 30 mils thick.

The plates are bright to semibright. Depending on the finish of the base metal, plates up to about 5 mils thick are very smooth and thicker plates are only slightly rough.

Porosity of the plates is especially low. When various plating thicknesses were tested they were signifi-

Welding aluminum waveguide—Welding engineer at the metallurgical laboratories of Olin Mathieson Chemical Corp., 460 Park Ave., New York 22, uses an improved MIG spot welding gun to fabricate an aluminum alloy waveguide for electronic equipment. Refinements made by the company's metallurgical laboratories are said to make the MIG spot welding process much more useful to fabricators of aluminum products. The results: more rapid production, substantial labor and equipment savings, and better product appearance.

The MIG spot welding process was developed during World War II for joining steel, and was later adopted for joining aluminum and stainless steel (*Materials & Methods*, Jan '50, p 54). **KEY NO. 610**



26

EMBOSSED DESIGNS IN 6 METALLIC COLORS...

BACK PEELS OFF FOR ADHESION ▼

Available in
• CHROME • GOLD
and COLORS
with or without
ADHESIVE BACKING

Choose from the largest variety of laminations, gauges and special effects in the field. Available in continuous rolls, cut-to-size sheets, die cuts or in widths as narrow as 1/4 inch.

Our design engineering department will assist you in selection and application to meet your individual needs. No cost or obligation.

ALL FABRICATION DONE BY US EVERY STEP OF THE WAY

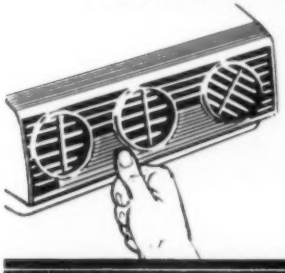
Every process in the fabrication of Mirro-Brite Mylar is done in our own factories... metalizing, coating, embossing, printing and lamination. This insures uniform quality control plus significant savings to you.

PRESSURE SENSITIVE MIRRO BRITE

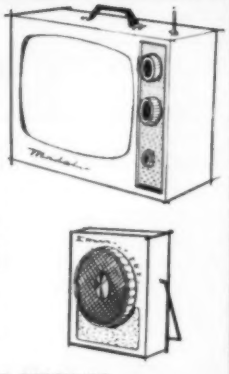
MADE WITH "MYLAR"* IN ROLLS SHEETS STRIPS DIE CUTS

*Ready Strip

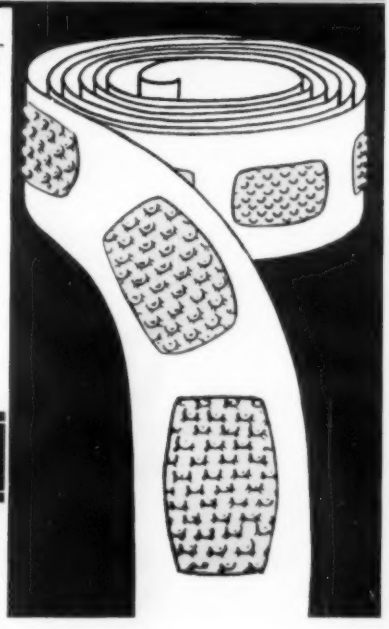
ADHESIVE BACKED MYLAR PARTS



Decorative metalized trims pre-cut to your exact size and shape in continuous rolls. Peel off and press on! A big time saver on your production line.



WRITE FOR FREE SAMPLER BROCHURE



COATING PRODUCTS, INC.

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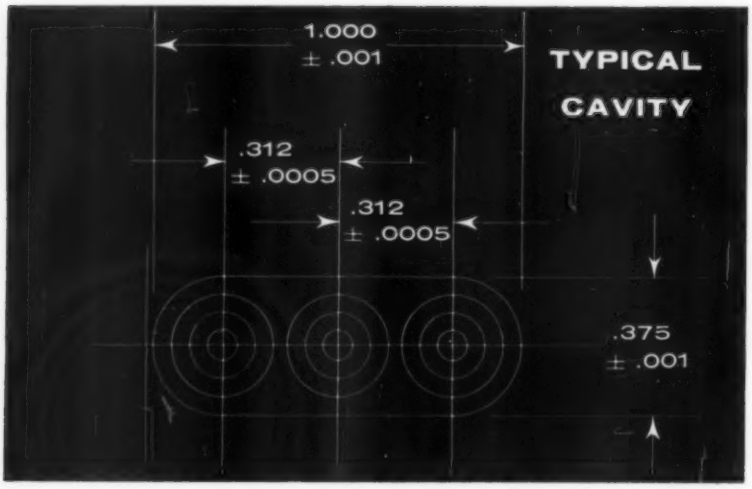
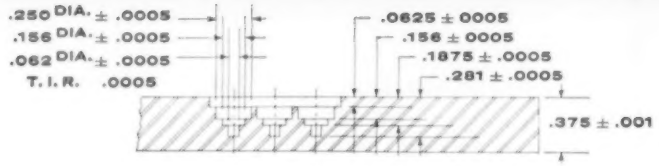
NEW JERSEY: LOwell 8-0610 NEW YORK: WIsconsin 7-4435

*A DuPont Polyester film

"PIONEERS IN METALIZED MATERIALS"

For more information, turn to Reader Service card, circle No. 405





UNBELIEVABLY CLOSE TOLERANCES

on graphite jigs and fixtures
. . . but Speer can hold them!

Here are a few examples—

- **Concentricity of drill holes to .0005 T. I. R.**
- **Drilled holes as small as .005 held to ± .0005**
- **Depth of holes held to ± .0005**
- **Oblong or "pork-chop" type cavities—length and width held to ± .001, depth held to ± .0005**

Combine Speer's superb machining skill with the wonders of Speer Graphite itself and you have the perfect solution to many high-temperature problems. Graphite actually gets *stronger* as it gets hotter . . . does not warp . . . will not split or break down under severe thermal shock. It is chemically inert and is not wet by molten metal or glass. Speer Graphite is the ideal material for many high-heat applications, such as transistor jigs, fusing positioners, honeycomb jigs, furnace fixtures, brazing jigs, glass-to-metal seals.

BRING YOUR PROBLEMS TO SPEER! Years of experience in solving tough high-temperature forming and positioning problems with graphite, plus Speer's unusual fabricating skill, provide hundreds of answers for the aircraft, electronics and powdered metals industries.

To obtain full information on Speer Graphite and Speer machining facilities in relation to your specific requirements, send us your detailed blueprints. Your inquiry will receive prompt attention.

SPEER Carbon Co.

CARBON PRODUCTS DIVISION
ST. MARYS, PENNSYLVANIA

Products of the Carbon Products Division include:

Brushes for Motors & Generators • Carbon & Graphite Specialties • Electronic Tube Anodes • Flashlight & Battery Carbons • Plates & Rods • Rocket & Missile Components • Ultra Pure Graphite

For more information, turn to Reader Service card, circle No. 453

cantly less porous than comparable plates made by four other gold plating methods.

Steel and copper specimens plated with 1 mil of gold by the new process withstood boiling in concentrated hydrochloric and nitric acids without showing any weight loss.

Thin gold—The thin gold plating process uses sodium gold cyanide with citric acid and/or ammonium gold citrate.

The process has been used by R. A. Ehrhardt, Bell Telephone Laboratories, Murray Hill, N. J., to gold plate copper printed circuit elements.

One of the main problems in plating printed circuit conductors is preventing the plating solution from damaging the circuit board or seriously weakening the plastics substrate.

Copper circuit elements are gold plated for several reasons: to assist fluxless soldering, to provide a good electrical contact surface, and to resist the reverse-etch process.

Electroplates ranging from 0.003 to 0.1 mil thick have been successfully produced. The porosity of these plates, although quite low, is dependent on the quality of the base material.

2. New sulfamate solutions

Previous success with sulfamate solutions for plating nickel and lead prompted R. C. Barrett, president, Barrett Chemical Products Co., Inc., Shelton, Conn., to use similar solutions for plating cadmium, cobalt and iron.

Cadmium—A stock solution of cadmium sulfamate was made by reacting high purity cadmium carbonate with sulfamic acid: pH was increased by adding more cadmium carbonate or lowered by adding more sulfamic acid. Two experimental baths were made from these solutions (in oz per gal):

	A	B
Cadmium sulfamate	42.0	42.0
Cadmium (metal content)	15.3	15.3
Boric acid	4.0	—
Nickel sulfamate	—	0.25

Both baths were operated at room temperature in the pH range 3.5 to 4.5. Anodes were ¼-in. thick electrolytic cadmium which corroded smoothly at 100% anode efficiency.

Cadmium deposits from the two

you can tap the world's largest rubber tree

It would take more than 100 million rubber trees—a vast "plantation" covering more acreage than Connecticut and Delaware combined—to match the productive capacity of Goodrich-Gulf. Our two strategically located plants together can produce enough Ameripol rubber in a year to make 70,000,000 passenger car tires . . . or to make a 4-foot-wide rubber belt stretching from New York to Honolulu and back. What does this mean to you? Just this. The quality and quantity of synthetic rubber you need for your production, when you need it. In other words, a guaranteed source of supply. As American industry's appetite for man-made rubber grows (over 65% of all rubber consumed is now synthetic), Goodrich-Gulf is more than ready to meet the demand with the world's largest capacity for producing synthetic rubber.

Goodrich-Gulf Chemicals, Inc.

1717 East Ninth Street, Cleveland, Ohio • Plants at Port Neches, Texas, and Institute, W.Va.

For more information, turn to Reader Service card, circle No. 443

If you have a tough corrosion problem and need wire cloth or wire cloth parts, here's a source of supply that knows the answers. We are proud of the quality of our cloth...accurate mesh count, close tolerance wire diameter, precision weaving...plus the know-how necessary to specify the proper alloy for **your** service conditions.

NEWARK for ACCURACY

Write or call us today if you have a problem calling for anti-corrosive wire cloth or wire cloth parts. Send for Bulletin F-C.

Newark Wire Cloth COMPANY

351 Verona Avenue • Newark 4, New Jersey

For more information, turn to Reader Service card, circle No. 414

What's new IN MATERIALS

baths had large, coarse grain structures. But in spite of the large grain structure, the cadmium deposits showed higher density and less porosity than deposits from other electrolytes.

Although the denser cadmium deposit provides greater corrosion protection, it can lead to hydrogen embrittlement since hydrogen cannot be effectively outgassed.

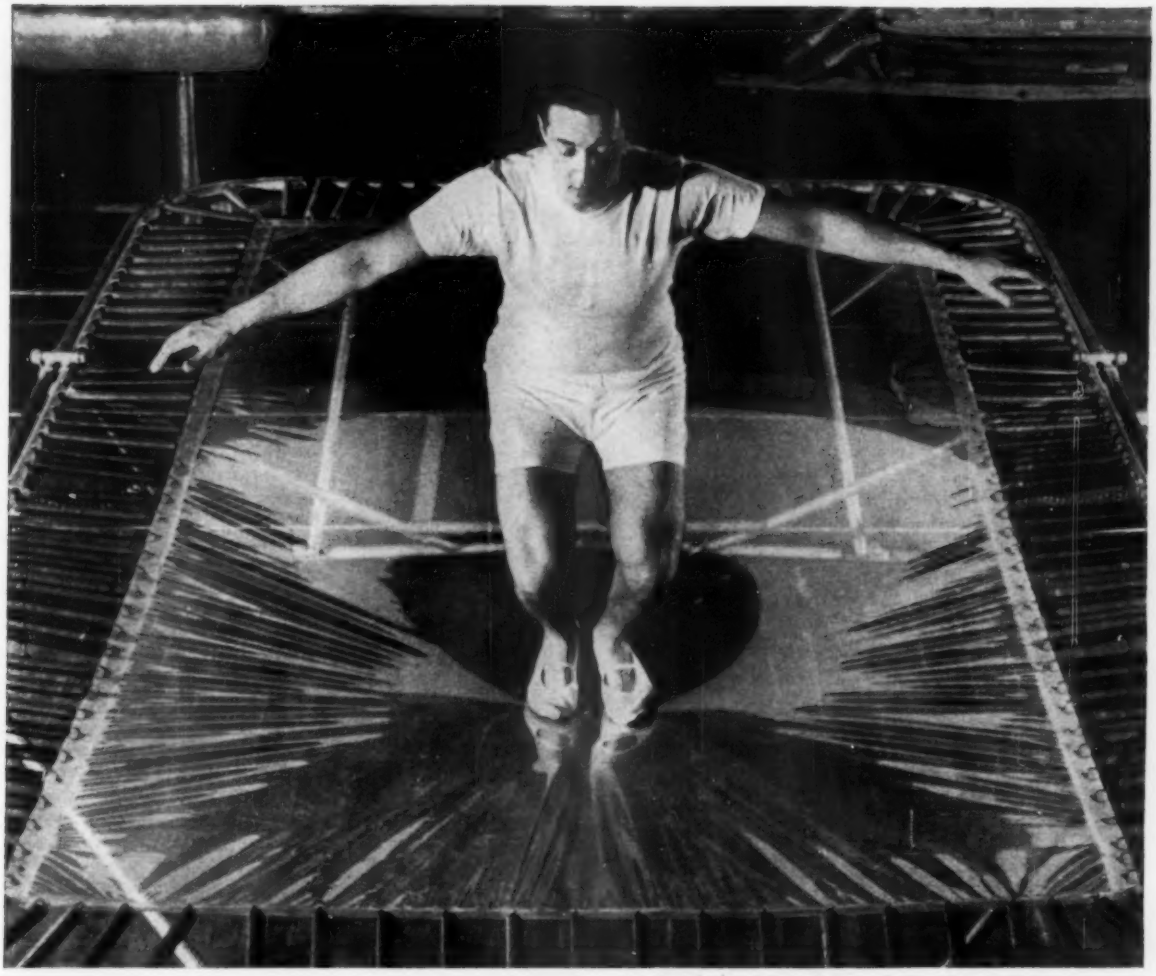
Maintenance and control of the cadmium sulfamate plating bath is simple and easy, according to Barrett.

Cobalt—Sulfamate solutions have been used successfully to deposit cobalt and cobalt-nickel alloys on magnetic memory tapes. Cobalt-nickel deposits 0.0000025 in. thick have been used on 0.001-in. thick phosphor bronze magnetic tapes for high frequency character storage as well as video and high fidelity sound recording.

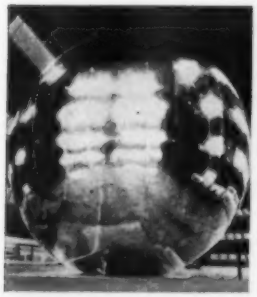
The formula for a cobalt-nickel alloy bath for plating magnetic re-

King size pigs of high purity and Prime Western grades of zinc—weighing 2500 lb—are available from the New Jersey Zinc Co. Two design features make handling of the 36 x 28 x 16-in. pigs easier: tapered holes in the top to accommodate crane hoist tongs, and legs and wings to allow lift truck prongs to be placed in either of two directions.

KEY NO. 611



Tough, durable Mylar® cuts costs... improves product performance



1. Huge (100 ft. diam.) inflatable satellite of metalized "Mylar" stays strong and flexible in sub-zero outer space.

2. Permanent collar stays of "Mylar" last the life of the shirt . . . keep their shape even after hundreds of launderings.

3. Capacitors with insulation of "Mylar" give long-lasting reliability . . . need for costly encapsulation is eliminated.

For example, "Mylar"* polyester film gives many products extra resistance to heat, cold and aging . . . lengthens their life. Today, "Mylar", with its resistance to chemicals and moisture, is improving the performance of products as different as surgical bandages and intercontinental ballistic missiles.

Can this unique plastic film and products made with it help you? For more information on "Mylar", write the Du Pont Co., Film Dept., Room S-8, Wilmington 98, Del.

DU PONT

*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

Better Things for Better Living . . . through Chemistry

DU PONT MYLAR® POLYESTER FILM

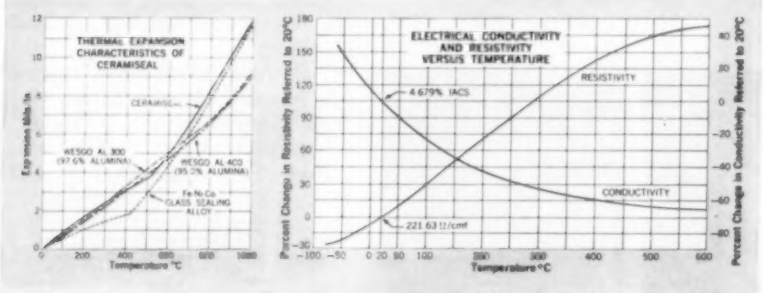
For more information, turn to Reader Service card, circle No. 341

WBD CERAMISEAL®

The Better Metal for HIGH ALUMINA CERAMIC SEALING

CERAMISEAL (U. S. Pat. No. 2,960,402)
Chemical Analysis: 25% Cobalt, 48% Iron, 27% Nickel

Specially designed by WBD for ceramic-to-metal sealing, CERAMISEAL alloy has expansion characteristics closely matching those of high temperature alumina ceramics. Low thermal conductivity, approximating that of ceramics, minimizes thermal stresses during rapid heating and cooling cycles. CERAMISEAL is readily brazed, deep drawn and machined; is supplied (air or vacuum melted) in wire or strip.



Call or write for Ceramiseal Bulletin and information on other WBD Sealing Alloys.

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PRECISION RESISTANCE, ELECTRONIC AND MECHANICAL ALLOYS FOR ALL REQUIREMENTS

For more information, turn to Reader Service card, circle No. 391

What's new IN MATERIALS

cording tapes is (in oz per gal):

Cobalt sulfamate	30.0
Nickel sulfamate	30.0
Boric acid	4.0
Magnesium chloride	2.0
Anti-pit agent	0.05

The bath has a cobalt-nickel alloy plating ratio of 80% cobalt, 20% nickel. It is run at room temperature at a pH between 2.0 and 4.0. Deposits from the bath are blue-white in thin films and dark matte in thicker deposits.

Tensile stress in a 0.0006-in. thick deposit is 14,600 psi. This high tensile stress can be relieved by annealing the deposit at temperatures from 400 to 475 F.

Iron—Tests by Barrett showed that an experimental iron sulfamate plating bath can produce fine grained, ductile iron deposits with good color. The formula for the plating bath (in oz per gal) is:

Ferrous sulfamate	53.2
Iron (metal content)	13.3
Ammonium sulfamate	4.0
Formaldehyde	1.3

The iron sulfamate solution can be mixed with either nickel or cobalt sulfamate solutions to produce alloy plating for special magnetic purposes.

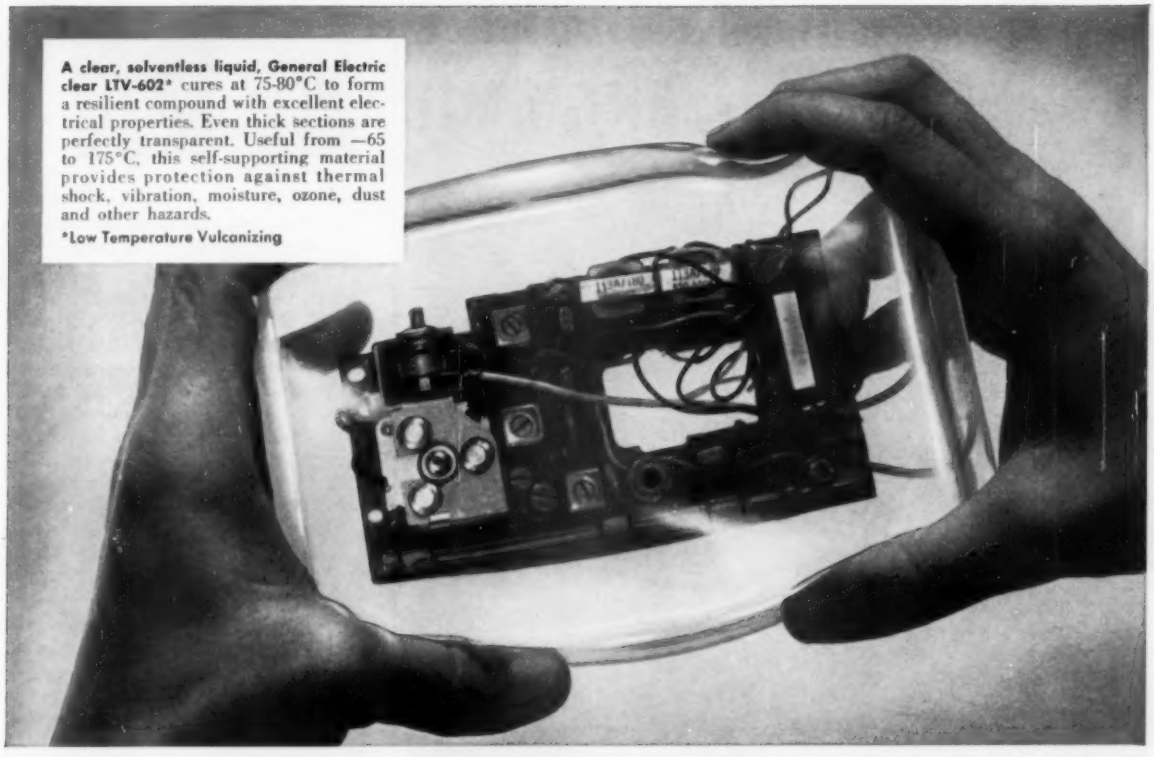
Tubes Extruded from Aluminum Ingots

Collapsible aluminum tubes are now being made automatically from primary aluminum ingots at the White Metal Mfg. Co. plant in Hawthorne, N.J. The operation was made possible by a unique rotary casting machine that makes continuous strip from ingots.

A big advantage of the process is that it enables relatively small manufacturers to make extrusions directly from ingots instead of buying the metal already formed into slugs. The process is a joint development of White Metal and Aluminium Ltd.

How it works

An aluminum ingot (99.8% purity) is melted in a gas-fired furnace and drawn out through a trough to a slowly revolving casting wheel. The wheel has on its face a mold cavity. Molten metal is poured into the cavity where it is contained by a

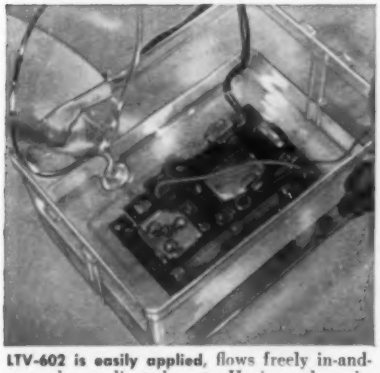


A clear, solventless liquid, General Electric clear LTV-602* cures at 75-80°C to form a resilient compound with excellent electrical properties. Even thick sections are perfectly transparent. Useful from —65 to 175°C, this self-supporting material provides protection against thermal shock, vibration, moisture, ozone, dust and other hazards.

*Low Temperature Vulcanizing

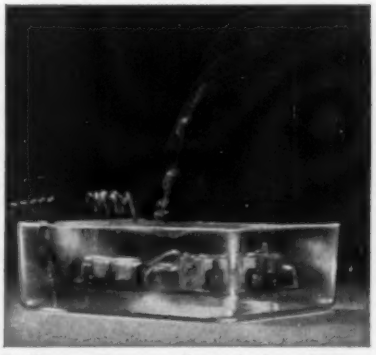
General Electric clear LTV silicone compound for potting and embedding

Transparent, resilient, self-supporting and easy to repair



LTV-602 is easily applied, flows freely in-and-around complicated parts. Having a low viscosity in the uncured state, 800-1500 centipoise, LTV is ideal for potting and embedding of electronic assemblies. Unlike "gel-like" potting materials, LTV-602 cures to a flexible solid. Oven cure is overnight, or from 6 to 8 hours at 75 to 80°C.

LTV-602 is easy to work with and easy to repair. To repair parts embedded in LTV, merely cut out and remove section of material, repair or replace defective part, pour fresh LTV into opening and cure. Pot life, with catalyst added, is approximately 8 hours and may be extended with refrigeration. When desirable, LTV may also be cured at room temperature.



Resiliency offers excellent shock resistance. LTV-602 easily meets thermal shock tests described in MIL-STD-202A test condition B which specifies five temperature cycles from —65 to 125°C. Tests indicate that LTV retains protective properties even after 1800 hours aging at 175°C. Other tests confirm LTV's resistance to moisture and water immersion.

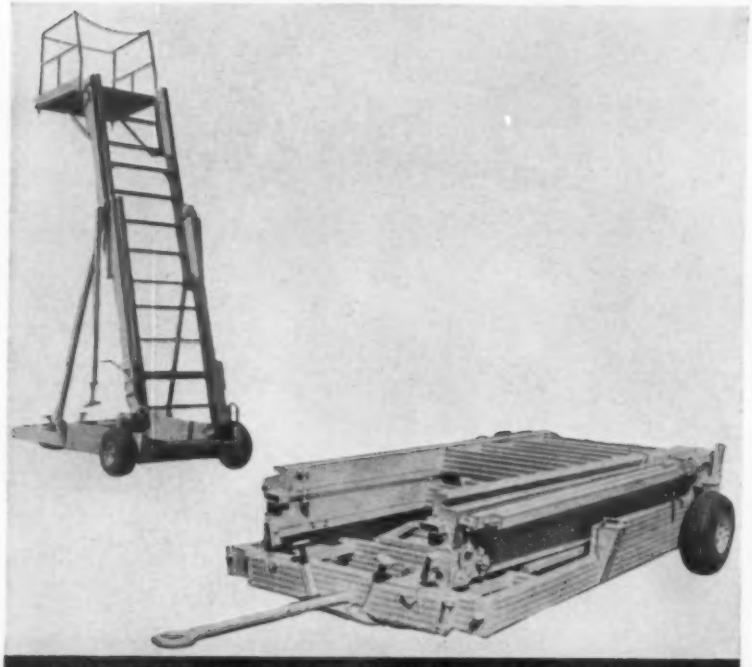
LTV-602 is the newest addition to the broad line of G-E silicone potting and encapsulating materials which also include the RTV silicone rubbers. For more information, write to General Electric Company, Silicone Products Department, Section B340, Waterford, New York.

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 373

LUBRICATION REPORT

(TFE coating)



Application: *Portable Aircraft Maintenance Stand Lubrication.*

Problem: *To Minimize sliding friction at widely varying temperatures.*

Solution: *'EMRALON® 310 (a tetrafluoroethylene pigmented, bonded film lubricant) — spray-applied and baked at 300° F. for one hour.*

RESULT: *ALL-WEATHER COATING GIVES TELESCOPING STAND NEEDED LOW-FRICTION SLIDING SURFACES*

This lightweight portable aircraft maintenance stand was developed for use by the U. S. military forces by South River Metal Products Co., Inc., of South River, N. J. Approximately 40 lineal feet of telescoping surfaces are contained in the stand which elevates to 13 feet for use, and compacts to a height of only 2 feet for transporting. Tests showed that the sliding magnesium sections were readily subject to galling and seizure. The dry-film coating obtained with Acheson's 'EMRALON' 310 provides the necessary lubrication through an ambient range from desert heat to Arctic sub-zero temperatures . . . and does not cake, evaporate or freeze.

Perhaps one of Acheson's series of TFE coatings can help solve your dry-film lubricating problem. Write for 'EMRALON' 310 or 'EMRALON' 320 (air dry) Product Data Sheets. Dept. ME3.

ACHESON – First name in solid lubricants for fifty-three years.

ACHESON Colloids Company

PORT HURON, MICHIGAN

A division of Acheson Industries, Inc.
Also Acheson Industries (Europe) Ltd. and affiliates, London, England.
Sales offices in principal cities.

For more information, turn to Reader Service card, circle No. 346

What's new IN MATERIALS

steel belt and gradually solidified by water spray as the wheel turns.

The aluminum emerges from the wheel cavity as a continuous strip ¾-in. thick by 8 in. wide and goes directly to the first of two rolling mills. Finished strip ranging in thickness from 0.150 to 0.250 in. is automatically wound into coils and delivered to an automatic slug blanking press. The press blanks out slugs which are carried through a washer and annealing oven. After annealing, the slugs are fed to impact extrusion presses which form them into tubes.

Three-quarters of a million tubes are being turned out daily at the Hawthorne plant by the highly automated production line. According to a company spokesman, the metal is not touched by human hands from the time it enters the furnace to the final inspection of the finished tubes.

KEY NO. 612

***Rotary casting** aluminum for processing into collapsible tubes.*

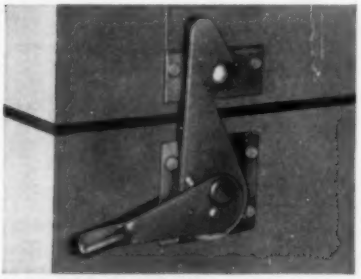
Forming Lubricant Effective up to 2200 F

A new lubricant is said to prevent galling, scoring and metal pickup in forming steel, copper and exotic metals at temperatures up to 2200 F. The lubricant, called Phosphatherm RN, is available from Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.

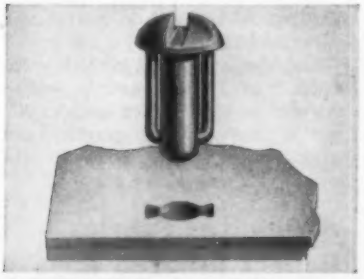
The lubricant is a mixture of cer-

ANSWERS to specific fastening problems ...by SIMMONS

Economy, design flexibility, quick and easy installation, strength, and smooth, dependable action are advantages of these Simmons Fasteners, made for a variety of special applications. Whatever your fastening problem, engineering aid is available from Simmons.

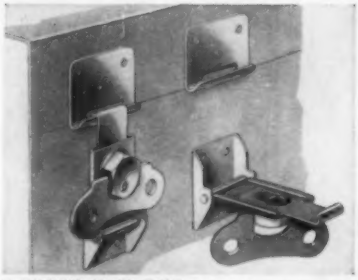


HOOK-LOCK–Springless, positive-locking latch which lies flat against mounting surface, open or closed. Provides high closing pressure and load-carrying capacity. For military as well as commercial container applications.

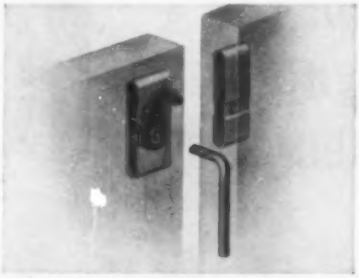


SPRING-LOCK–Perfect, proved blind rivet for removable covers and panels on electric and electronic equipment, sheet-metal automobile parts, appliances.

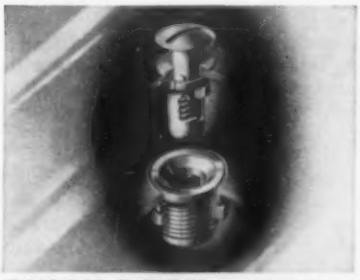
Plastic Spring-Lock Shelf Supports with "heart of steel" help refrigerator makers cut costs, speed production, simplify servicing.



LINK-LOCK–Ideal latching device where heavy locking pressure is necessary. Available in heavy, medium, light duty, for use in military and commercial containers and demountable construction.



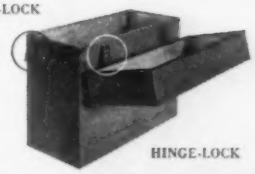
DUAL-LOCK–Impact and vibration-proof high-load butt-joint fastener that will not accidentally unlock or loosen. Recess in panels or surface mount. Withstands 7000-lb. tension.



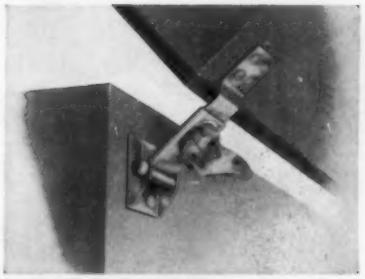
QUICK-LOCK–For assembling removable panels and access doors. Locked by a 90° turn. Various sizes and types, for weather-tight electrical units, cowlings, access panels.

SEND TODAY for your copy of the Simmons catalog, with specifications, applications, installation instructions for all Simmons Fasteners. Samples are available. For special assistance, describe your requirements.

LINK-LOCK

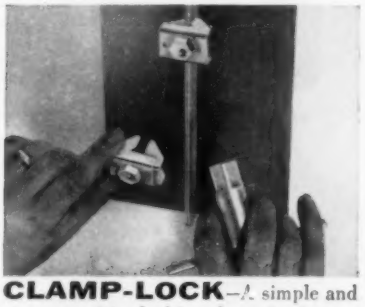


HINGE-LOCK



HINGE-LOCK–A rugged pressure hinge which provides a strong seal along the hinge line of gasketed equipment containers and transit cases. Matched hardware with LINK-LOCK.

ROTO-LOCK–Versatile fastener for butt or right-angle joints in portable shelters, partitions, knock-down shipping boxes, etc. Solidly built, springless.



CLAMP-LOCK–A simple and strong, positive-locking clamp for fast assembly (and disassembly) of permanent or temporary rooms and buildings of flanged-panel construction.

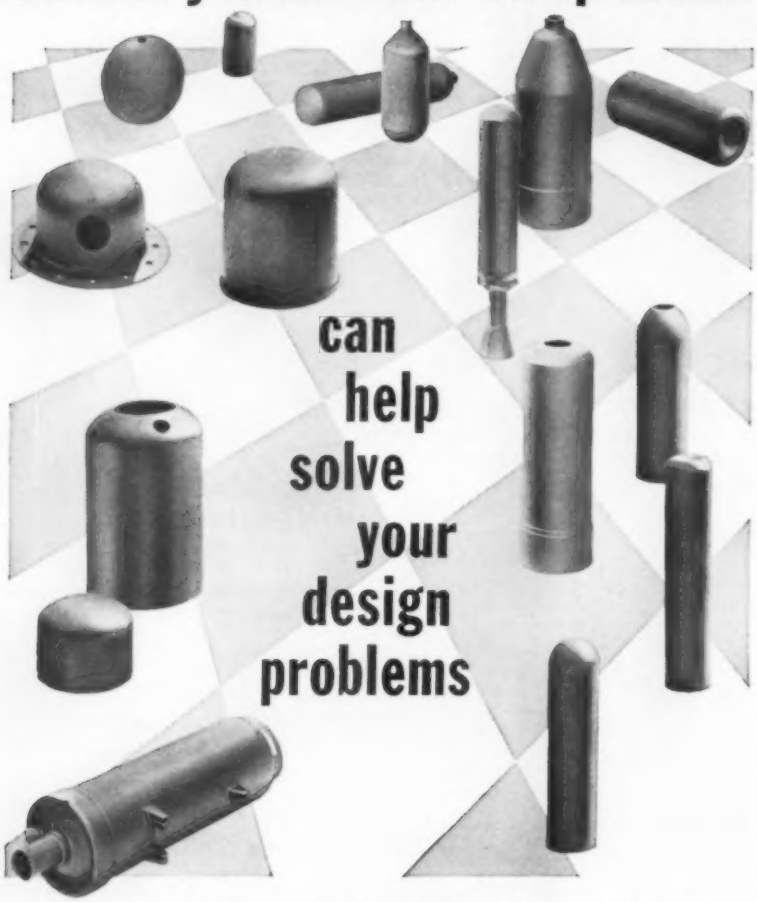
SIMMONS FASTENER CORPORATION

1759 North Broadway, Albany 1, New York

See our condensed catalog in Sweet's Product Design File

For more information, turn to Reader Service card, circle No. 365

Hackney seamless components



Whatever your shape or shell problem, the solution lies in Hackney deep drawn forming methods. There are two good reasons why:

First, Hackney components are produced the cold drawn way to insure strong, lightweight, seamless shells with smooth, clean surfaces; consistently uniform side walls, and closely controlled tolerances. That's what makes them completely dependable, completely reliable parts of your design.

Second, many of the sizes you need are quickly available because we have a large assortment of dies, mandrels and related tooling. And our experience and facilities are at your disposal to transform any of your design ideas into reality.

Why not let our engineers help you work out details and suggest ways to improve reliability and reduce costs. Your components can be formed in steel, magnesium, nickel, ultra-high-strength stainless steels, hot work tool steels, molybdenum or titanium. Units can be made in sizes from 1 qt. to 100 gal.; diameters range from 2″ to 32″; lengths may be from ½ to 5 times the diameter, or up to 110″. For complete information, write to the address below.

Pressed Steel Tank Company

Manufacturer of Hackney Products Since 1902

1442 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 324

What's new IN MATERIALS

tain phosphates and other salts, and is supplied as a dry white powder. The powder can be mixed with water and applied to metal surfaces that have been heated to temperatures above 400 F.

The producer says the lubricant is nontoxic, is no fire hazard, and generates no smoke or fumes. Lubricant residues can be removed from metal surfaces with cold water.

KEY NO. 613

Sanitary Vinyl Film

A new type of vinyl film recently introduced by Goodyear Tire & Rubber Co., Akron, Ohio can be used to convert a truck bed, railroad car or ship's hold into a sanitary container for liquids and foodstuffs.

The producer says the raw material from which the film is made meets the rigid standards set by the Food and Drug Administration for products to be used in conjunction with foodstuffs.

The film is supplied in thicknesses from 3 to 16 mils and in widths from 36 to 72 in. Price is 60 to 70¢ per lb depending on quantity and gage. KEY NO. 614

Aluminized Fabrics Reflect Infrared Rays

Protection of equipment and personnel from high radiated heat is possible with new aluminized, silicone rubber-coated glass fabrics now available from Irvington Div., Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

The fabrics, called SRGA, reflect more than 90% of the infrared rays generated by a thermal source.

Fabrics protect cable

The SRGA fabrics are used as a protective curtain to shield complex electronic devices, personnel, heavy equipment, sensitive circuits and cable from destructive heat. In one application, electrical cable shielded with the fabrics placed 3 ft from a 2300-2800 F jet exhaust blast remained operational after 25 sec: conventionally shielded cable burned out and disintegrated in the test.

Flexible, reflective

The materials consist of a coating

Special Ray-BOND® Adhesive

BONDS GLASS TO PLASTIC

To reduce breakage and assembly time of glass vacuum bottle fillers, The American Thermos Products Company, Norwich, Connecticut, undertook to replace an aluminum cap with a polyethylene protector for the evacuation tip of the glass filler.

The problem was bonding the traction-free polyethylene to the smooth glass surface. Existing adhesives couldn't do the job. R/M adhesive specialists, working closely with Thermos Company engineers, quickly developed a special adhesive.

The result is a superior bonding agent, R/M's new R-84002, for "Mylar," polyethylene, glass and other slick-surface, bond-resistant materials. Based on a thermoplastic synthetic resin, R-84002 has temperature tolerances ranging from −20 to +200°F.

Regardless of your application Ray-BOND adhesives of new or existing formulations can be tailored to your special bonding, laminating, sealing or coating requirement. Your costs are reduced; your production is improved. Let us prove this to your satisfaction. Call on Raybestos-Manhattan engineers today without obligation.

R/M Bulletin No. 700 contains helpful engineering information on Ray-BOND adhesives, protective coatings and sealers, and casting, encapsulating and potting compounds. Write for your free copy.

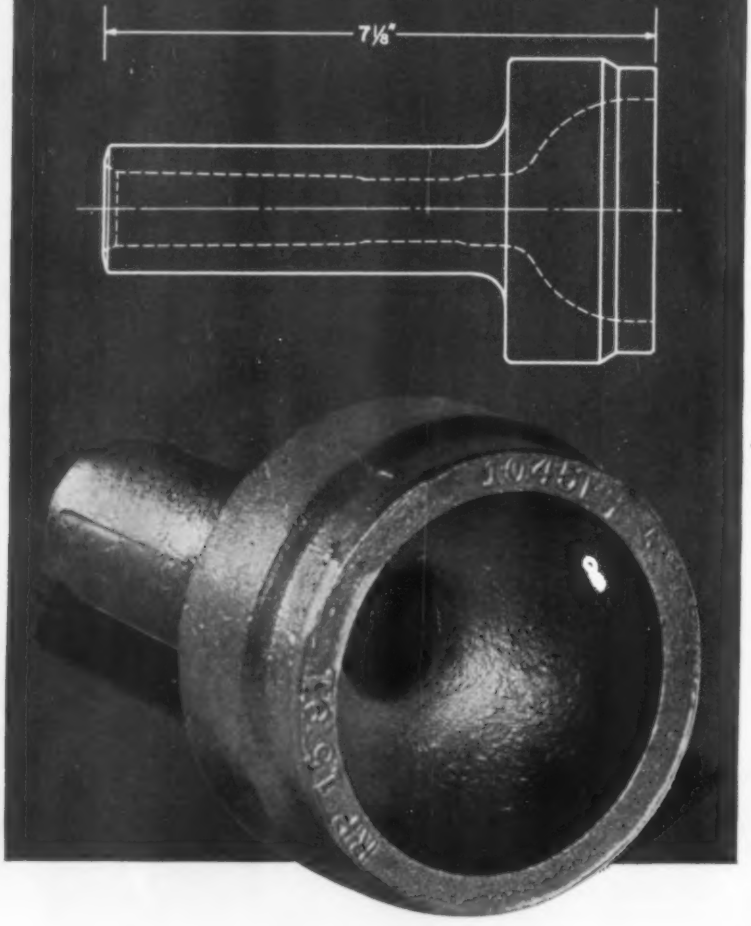
RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT, Bridgeport, Conn. • Chicago 31 • Detroit 2 • Cleveland 16 • Los Angeles 58

For more information, turn to Reader Service card, circle No. 387

PROBLEM:

Excessive drilling and machining on vital defense forging.



SOLUTION:

AmForge engineers offered a design using new upset techniques.

The head was forged closer to final tolerances, cutting down machining time. The stem was pierced, eliminating a costly drilling operation.

Slight forging cost increase was more than offset by saving in machining. Also, strength was added to the critical stem by controlling distribution of metal and grain flow during piercing.

If you have a similar problem part, consult AmForge. Write for our new brochure and the name of your nearby AmForge sales engineer.

Remember: *your problems . . . our challenge!*

AM FORGE

a division of American Brake Shoe Company, 1220 West 119th Street, Chicago 43, Illinois. Two plants in Chicago, one in Azusa, California

WHEN IT'S A VITAL PART, DESIGN IT TO BE FORGED

For more information, turn to Reader Service card, circle No. 332

What's new IN MATERIALS

of vaporized aluminum laid over one side of a silicone rubber-coated glass cloth base, adding a highly reflective face while retaining flexibility and drape in the cloth. The specially woven and treated glass base cloth is said to provide sturdiness and dimensional stability, as well as resistance to tearing, bursting and creasing. The silicone rubber coating is specially formulated to further limit the temperature rise of the fabric through an irreversible endothermic process.

Three fabrics available

SRGA 0208 and 0214 are 0.008 and 0.014 in. thick and weigh 10 and 14 oz per sq yd, respectively. They are suitable for continuous use at temperatures ranging from –100 to 500 F, and for short periods at 700 F.

SRGA 0213 is designed for short time protection against high radiant energy. According to 3M, the fabric withstands exposure to black body temperatures as high as 6000 F.

KEY NO. 615

Spot Plating Technique

A new spot plating process for touch-up and other jobs has been introduced by Selectrons, Ltd., 520 5th Ave., New York 36. The technique appears to be similar to one introduced some time ago by Dalic Process Co. (*Materials & Methods*, Dec '54, p 98).

The spot plating technique is particularly well suited for 1) prototype work where new solutions are to be tried, 2) production work when large parts need plating in small areas, and 3) maintenance and repair.

Plating solutions are sold in pint or quart containers, and plating styluses are available in a number of sizes and shapes. KEY NO. 616

Zinc Improved for Lithographic Plates

Three new developments in zinc lithographic platemaking are said to greatly increase the virtues of zinc alloy sheet for printing purposes. The developments, announced re-

SILICOLOGY

Studies in Silicones

HOW THESE TIME-TESTED MATERIALS CAN WORK FOR YOU

Silicones Go Into High Gear... To Back Up the New Car Warranty

Automobile designers sharpened their pencils for the 1961 models. The new "12-months-or-12,000-miles" warranty calls for much more than a new piece of paper. Needed is the kind of extra assurance that products such as silicones provide to back up performance.

With this new look at quality control, UNION CARBIDE Silicones are becoming more popular with designers, production engineers, dealers, and most important, with customers. Yet these high-performance products usually cost only a few cents more than most of their out-dated counterparts.

SILICONE RUBBER SETS NEW STANDARDS

Silicone Rubber, in various compounds, performs better than organic rubber in many areas. Among other things, it stands up under extremes of heat and cold, yet permits precision molding at favorable fabricating rates.

Silicone rubber sparkplug boots remain unaffected by water, heat—even ozone—for a maximum service life. Other compounds work just as well as dielectric coating on battery terminals and distributor caps. And a special electrically conductive silicone rubber is used as ignition wire core on many models, reducing car radio interference below annoying levels. In transmissions and differentials, silicone rubber seals and gaskets stay on the job in spite of attack from oil, hydraulic fluids, anti-freeze—under conditions of elevated temperature.

CLOSE-UP of compact engine in Chrysler Motor's new 1961 Valiant series.

LOOK WHAT SILICONE FLUIDS CAN DO

There are an amazing number of places where silicone fluids work to reduce production costs and to boost the performance of the finished car. We can mention only a few.

To begin, silicone anti-foams in coolants and cutting oils keep costly, efficiency-robbing foaming of these agents to a minimum. In the production of tires, rubber floor mats, molded rubber accessories and radiator hoses, there are silicone release agents which help the finished product slip easily and quickly from intricate molds without loss of detail.

In the car itself, silicone damping fluids frequently keep delicate instruments from bouncing around, even when road conditions are extremely rough. In certain cars, variable-speed drive systems for the cooling fans use silicone fluids for powering because these remain stable over wide ranges of temperature. Among other things, silicone fluids are excellent leveling agents for acrylic lacquers . . . all-weather lubricants for car weatherstripping . . . and excellent constant-viscosity lubricants in special applications.

MORE TO COME FROM RESEARCH

There are hundreds of other ways in which silicones are serving the automotive industry. Every day, new uses are coming from research, more are being developed in the laboratory. Perhaps there is a place where your own operation can use them profitably, to improve product performance and production efficiency. We suggest you send the coupon below for further information related to your specific needs.

THE 1961 VALIANT Two-Door Hardtop, a new model in Chrysler Motor's Compact Car V-200 series, uses Silicone Products in many areas to improve the reliability, durability, and reduce production costs.

UNION CARBIDE

SILICONES

UNION CARBIDE is a registered trade mark of Union Carbide Corporation.

Silicones Division
Union Carbide Corporation
Dept. CM-0102
270 Park Avenue, New York 17, N. Y.
In Canada: Union Carbide Canada Ltd., Bakelite Division, Toronto 12.

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For more information, turn to Reader Service card, circle No. 460

How to buy steel rings . . .

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Find out about his background . . . experience . . . manufacturing facilities . . . how close he can come to meeting your specifications . . . what engineering assistance he can provide.

put your plans in his hands

When you have found this experienced, reliable supplier, send him your drawings. Give him complete details on materials, shape, tolerances you require, nature of application, and the performance you expect.

then let him assist you

If Edgewater is your choice, you will find that we will follow your specifications exactly. If required, we can furnish engineering assistance and suggest the material, shape and size to give you the ultimate in performance and economy.

want more details? Write for the Edgewater brochure, which describes our facilities, know-how, and range of sizes and shapes.

Edgewater Steel Company

P. O. Box 478 • Dept. MDE • Pittsburgh 30, Pa.

For more information, turn to Reader Service card, circle No. 397

What's new IN MATERIALS

cently by John L. Kimberley, executive vice president of American Zinc Inst., are:

1. A simple and inexpensive technique for producing an ultra fine grain on zinc litho plates equaling or exceeding the fineness of any grain previously obtained on other materials. An additional feature of the technique is the automatic application of a corrosion protective film to the zinc plate during the graining cycle, thereby extending the service life of the basic plate.

2. A new wipe-on diazo coating for zinc that is practical and easy to apply.

3. A one-step ink developer that, after photographic exposure of the plate through a negative, develops the image and inks it, desensitizing the non-image areas at the same time. This eliminates a platemaking step and speeds up production.

Polyethylene Resins Intended for Films

Two new series of polyethylene film-grade resins have been announced by Dow Chemical Co., Midland, Mich.

No. 660E is a Type II, intermediate density resin designed specifically for overwrap and thin-gage applications. Dow says the resin produces a film of excellent clarity and surface gloss. It is available in medium and low slip formulations. **KEY NO. 617**

No. 561E through 564E are Type I, low density materials particularly suited for produce, textile and soft goods bags and other applications where impact and clarity are important. They are available in low, medium, high and extra high slip formulations. **KEY NO. 618**

Galvanized Sheet Is Easy to Weld, Paint

A differentially coated galvanized sheet features a corrosion resistant, hot-dip zinc coating on one surface and a smooth, spangle-free finish providing a good paint base on the other.

Designated Zincgrip DC, the new

The seams don't show

Beautiful fit, beautiful look, beautiful soft drink dispenser. Beautiful job of close tolerance molding by General American. Working from wooden patterns, General American engineers designed six individual moldings. The shrinkage of each separate part was calculated to the thousandths of an inch. General American made the tools with the same precision.

Result—when this soft drink dispenser is assembled the seams are practically unnoticeable. In addition, the selection of the proper plastic, combined with General American's skill in molding, provides a product with very good luster, high impact properties, excellent stain resistance—and a reasonable price tag.

If you have a part or product that could or should be made of plastics, consult General American. In plastics, *it pays to plan with General American.*

in this 6-piece soft drink dispenser

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street • Chicago 90, Illinois

Offices in principal cities

PLASTICS DIVISION GENERAL AMERICAN TRADE MARK

For more information, turn to Reader Service card, circle No. 412

For more information, turn to Reader Service card, circle No. 337

sheet combines paintability with good spot welding characteristics. It is now available from Armco Steel Corp., Middletown, Ohio.

Phosphate coating eased

The new galvanized sheet is compatible with phosphate paint bonding systems currently used in the automotive industry. Body assemblies including both cold rolled steel and Zincgrip DC can be treated for painting at the same time: previously, zinc-coated parts required special preparation for painting.

Armco says it has sharply improved the welding characteristics of galvanized sheet by coating only one surface with a standard weight of zinc. Twice the number of spot welds possible on regular galvanized sheet can be made on Zincgrip DC before welding tips have to be redressed.

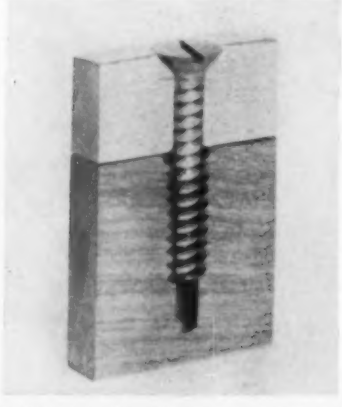
KEY NO. 619

Wood Fastener Has High Holding Power

A new fastening system for wood, particle board and related fibrous products is said to have up to two and one-half times the holding power of standard fasteners. The new wood fastening system was developed by Heli-Coil Corp., Shelter Rock Lane, Danbury, Conn.

Pitch is half that of standard screws

The insert fastener is a tightly wound coil of wire that is inserted



***Cutaway view** shows new wire insert in lower wood section with screw securely fastened in it.*

Which pre-paint phosphate coating is best for you?

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 FIELD SERVICE MEN • OVER 160 MATERIALS

Undercoat of Oakite CRYSCOAT adds to the looks and life of finishes

From toys to tractors, painted metal products look better and last longer with Oakite CrysCoat under the paint.

CrysCoating—the conversion of a steel surface to a phosphate surface—creates a perfect base for paint adhesion. Paint goes on in a smooth, serviceable coat. Once on, it stays on.

At the same time, a CrysCoated surface prevents the formation of rust . . . even prevents rust spreading from a deep scratch. Both metal and paint are safeguarded. The product looks better, lasts longer.

Oakite has a CrysCoat process to fit every requirement—for iron phosphate or zinc phosphate coatings, for spray washer or for tanks. Is your particular problem one of economy? Durability? Production bottle-neck? For a helpful answer, ask your local Oakite man. Or write for details to Oakite Products, Inc., 28A Rector Street, New York 6, N. Y.

it PAYS to ask Oakite

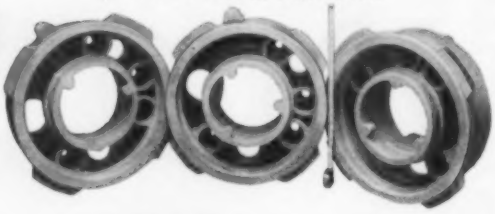
OAKITE

SCIENCE

over 50 *Est. 1909 years' leadership in industrial cleaning*

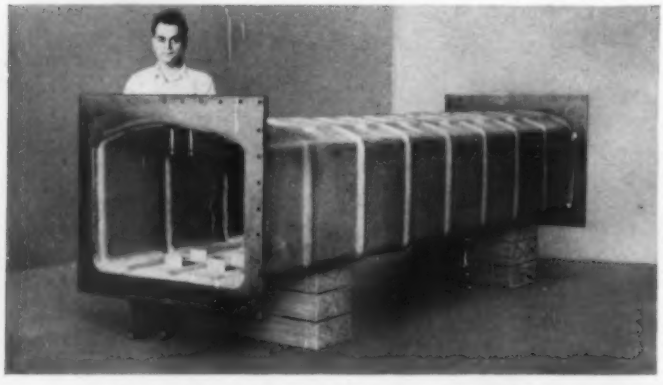
For more information, turn to Reader Service card, circle No. 366

special valve castings (Mi, Cr, Mo)



separator weighing about 2000 pounds

DURALOY



retort made up of welded sections, 1500 pounds weight

High Alloy CASTINGS for PROCESSING

- ***alloyed to meet high temperature and corrosive conditions.***
- ***soundly cast to make for highest safety under stress and pressure.***

Illustrated are three distinctly different Duraloy casting assemblies for process plant operations. They are typical of the great variety of castings turned out at our modern foundry and assembly shop.

With nearly forty years continuous experience in the field of high alloy castings, we can assure you of the best that can be obtained.

Send for Bulletin G-159.

ALLOY CASTING INSTITUTE ACI MEMBER

THE DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.

EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.

CHICAGO OFFICE: 332 South Michigan Avenue

DETROIT OFFICE: 23908 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 408

into a drilled hole for the accommodation of a screw. It has increased holding power because its pitch is half that of standard machine screws, allowing the insert to leave relatively thick sections of wood between the threads. The difference in pitch is said to stop the breaking-up of fibers between threads which contributes to the weakness of standard fasteners.

The wire thread insert is made of carbon steel which has been formed with a precision diamond-shape cross section.

How it is installed

1. A drilled hole is prepared in accordance with prescribed design and assembly specifications. The insert is wound onto a mandrel and screwed into the drilled hole with clockwise rotation and forward pressure.

2. The mandrel is reversed and unscrewed from the installed insert when it taps itself to the proper depth (one-half to one turn below the work surface). **KEY NO. 620**

Tough Tool Steels for Dies, Cutting Edges

Two new tool steels have been introduced recently by Crucible Steel Co. of America, P. O. Box 2518, Pittsburgh 22. One steel is designed for use in cutting tools and the other for use in dies. Composition of the two steels has not been revealed.

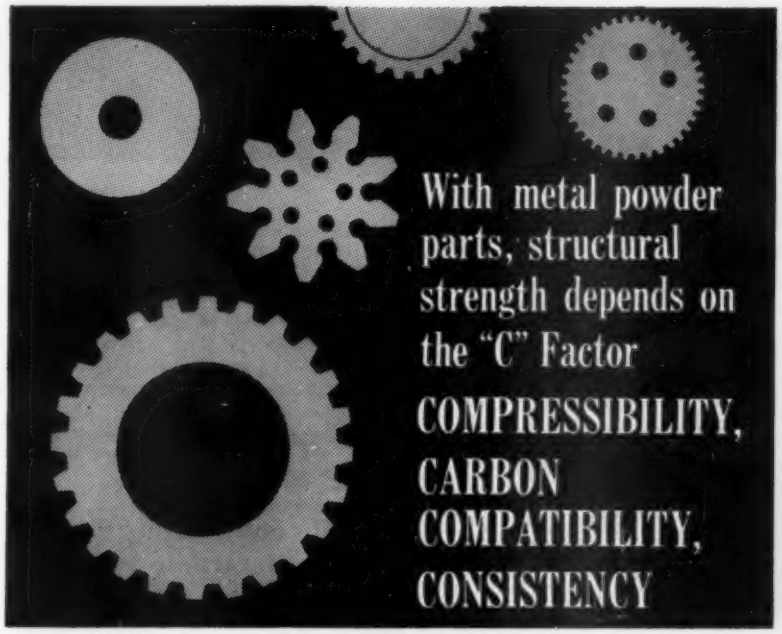
1. Steel for tools

Rex 49 is the name Crucible gives to its new high speed steel designed for use in cutting tools. The steel is expected to greatly increase life of tools used for cutting such materials as highly alloyed steels, stainless steels, superalloys and titanium. Tests show the new steel has outperformed the more expensive high cobalt and high vanadium tool steels in machining operations on many hard-to-machine metals.

The steel can be heat treated to a Rockwell hardness of C67-69. It sells for $2.07 per lb. **KEY NO. 621**

2. Steel for dies

The new die steel is an air hardening grade called Orbit. A big advantage of the steel is its low hardening temperature (1525-1600 F), permitting it to be heat treated in



With metal powder parts, structural strength depends on the "C" Factor

COMPRESSIBILITY, CARBON COMPATIBILITY, CONSISTENCY

For quality sintered parts and high density structural applications, select Easton RZ powders in the following grades:

Molding grade powders

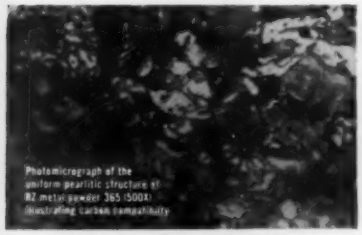
RZ 365
RZ 365—HD
RZ 365—M
RZ 365—P
RZ 365—S
RZ—200
RZ—4600 Alloy

"Sintrex" electrolytic grade powders

D—E—F

Custom powders

1. Preblends
2. Customer Specifications



...and only Easton's exclusive RZ iron atomizing process offers the "C" factor! Easton's molding grade powders produced by the RZ process flow better, compact more readily and extrude more easily than powders made by other processes. The flexibility of the RZ process permits variation in the density and surface characteristics of the metallic particles for optimum compressibility...controlled hydrogen loss contributes to high carbon compatibility for improved strength. Close control of chemistry and particle size distribution in the processing and final blending assures the homogeneity and complete consistency of each lot.

EASTON METAL POWDER COMPANY

Division of American Mannex Corporation

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CABLE CLIPS

of all nylon ....

for high heat or other severe conditions

of ethyl cellulose ...

for maximum economy in average conditions

Light weight, strong, chemically resistant. No short circuits, no grounds, no corrosion, no rust. Only one fastener needed Sizes to 1¼ inches. Write for free samples and price sheet.

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PLASTIC EXTRUSIONS... ANY SHAPE OR SIZE

Ace is one of America's leading mass producers of plastic extrusions and all types of precision parts. Any shape, form or color. Any type of plastic. Small runs or large runs. Huge stocks for immediate delivery. Quick, low-cost service on specials. Write, wire or call for samples, price lists and technical bulletins.

SINCE 1934 A EXTRUDERS FABRICATORS

ACE PLASTIC COMPANY 91-48 VAN WYCK EXPWY · JAMAICA 35, N. Y.

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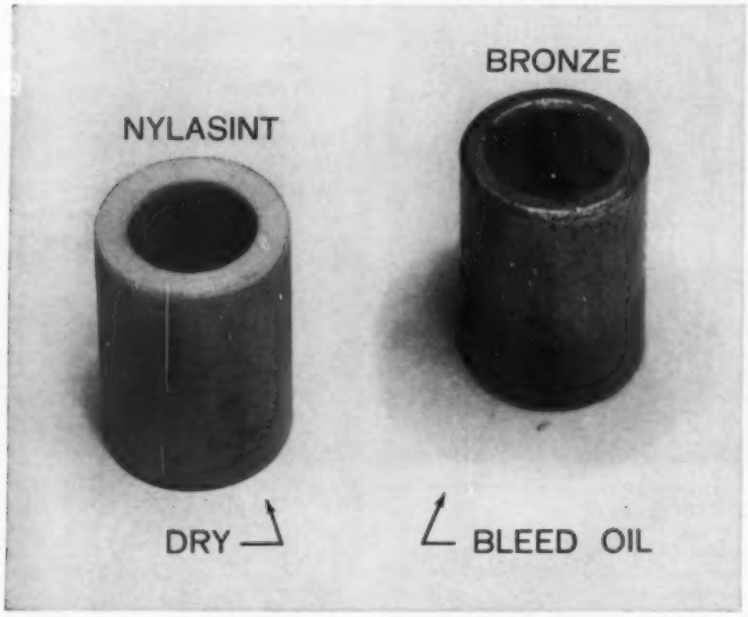
NYLASINT®. . . the only nylon with **permanent,** built-in oil lubrication



Even through wide temperature ranges and centrifugal speeds up to 1,000 Gs NYLASINT sintered nylon parts won't bleed.

Unlike oil-impregnated, sintered bronze which bleeds readily on paper (see above), NYLASINT holding up to twice as much oil is *permanently* lubricated to reduce friction, increase wear resistance and eliminate contact corrosion.

Inorganic additives also give resilient NYLASINT parts outstanding dimensional stability and high load capacity . . . important for such diverse fields as missile components and steel office furniture.

With NYLASINT you get all the prime advantages of nylon plus *extra* performance no other material offers in applications such as bearings, bushings, guides and washers.

For complete technical data on NYLASINT, call or write for new NYLASINT Bulletin BR-1111.

POLYPENCO® **INDUSTRIAL PLASTICS**

Halex Corporation

a subsidiary of The Polymer Corporation

Reading, Pa.

For more information, turn to Reader Service Card, circle No. 396

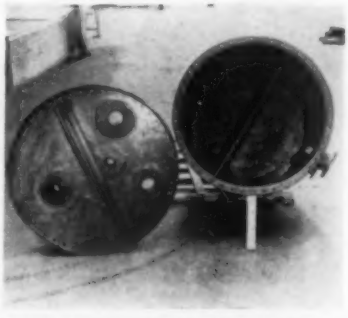
conventional furnaces. Most air hardening grades have to be heat treated at 1750 F or higher.

Free machining properties of the steel are said to give it 40% better machinability than conventional oil hardening grades used for the same applications. In addition, the new steel is said to be at least 10% tougher than conventional oil hardening grades. KEY NO. 622

Silicone Potting Resin for Electronic Parts

A clear silicone potting and embedding compound is said to provide mechanical and dielectric protection for electronic components and assemblies. The material, called LTV 602 (low temperature vulcanizing), cures to a flexible, resilient solid. It is available from General Electric Co., Silicone Products Dept., Waterford, N. Y.

Unlike jelly-like potting compounds, the cured compound is self-supporting and nonflowing. Thus it is easy to handle and excludes dust



Corrosion resistant plastic—Tanks like this one made of a new plastics compound are said to have excellent resistance to practically all acids and solvents, and to hot, concentrated solutions of sodium and potassium hydroxide. The new material, also suitable for pipes and ducting, was developed by Beetle Plastics Corp., Div. of Crompton & Knowles Corp., Fall River, Mass., and is called Bonate CF-9070. It is a modified furfural alcohol resin reinforced with glass fibers. The compound can be used at temperatures up to 300 F. KEY NO. 624

The adhesive strength of epoxy, the convenience of a pellet!

Epoxy, the world's strongest, most versatile adhesive, is now available in easy-to-handle, pre-measured **pellets!** Just set the E-Form pellet between **any two materials** (like to-like or like-to-unlike), raise the temperature and the unbreakable bond is achieved. No messy liquid, no guesswork, no waste. As strong as a weld, as quick as a wink. Whatever you are bonding together — metal, plastic, glass, wood — there is a pre-measured E-Form All-Epoxy pellet for your particular task. Cuts rejects, cuts production time, cuts costs. And **only Epoxy Products** makes E-Form pellets! Write today for details and samples.

EPOXY PRODUCTS

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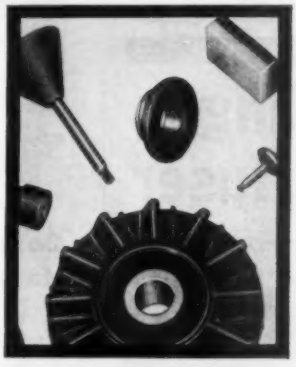
For more information, turn to Reader Service card, circle No. 437

get the **Goshen Rubber... IDEA***

*... to combine the best properties of rubber and metal in one bonded unit to meet YOUR PARTICULAR job requirement.



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Goshen's exclusive Gorbond process gives "designer-specified" adhesion between metal and rubber parts fabricated by GRC from natural, synthetic and silicone rubber compounds. The parts of metal (or other material) may be of customers' own design or manufacture. Your blue-prints and problems are welcome . . . for solution and quotation.

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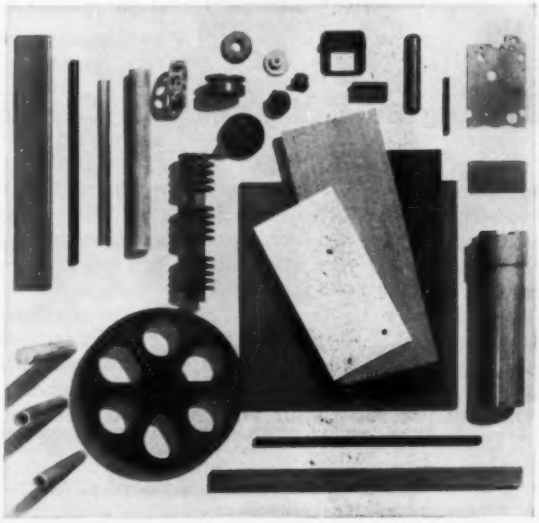
EVERYTHING in Laminated Plastics From One Source



An Example of
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From the day this plant started it has been shaped by the needs of customers like you. And so you find under one roof at Synthane your complete answer in laminated plastics—sheets, rods, tubes, molded-laminated, molded-macerated and fabricated parts. Synthane has all the facilities necessary for designing and producing tools, dies, jigs and fixtures for fabrication, a mine of information on the proper methods for machining laminated plastics. Versatility from one source. One high quality. One responsibility.

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Synthane Corporation, 3 River Rd., Oaks, Pa.

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Address_____

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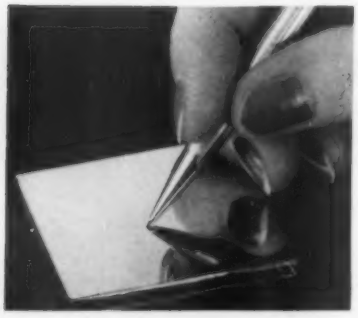
Vacuum-deposited aluminum coatings give perfect reflections without double images



Front-surface mirrors for optical, commercial and scientific uses give a single reflection of high perfection. Back-surface mirrors may reflect a second image from the front surface of the glass.

The reflective aluminum deposit is coated with hard quartz to increase durability. These mirrors withstand temperatures of 200° F. Also resist moisture and salt atmosphere far better than chemically silvered mirrors.

Other vacuum-deposited coatings are chrome and gold front-surface mirrors, neutral filters, transparent mirrors, hi-efficiency beam splitters, beam-splitting dichroic mirrors and filters. Metallic and transparent electrically conducting coatings are available for resistance heating. Static dissipating and high-frequency shielding coatings are also available.

Applied to glass, metal or plastic, the coatings are used in such varied products as scientific and optical instruments, toys, cameras, pin setters, wheel-aligning equipment, aircraft and missiles. If you have a potential application or new use, Liberty Mirror engineers will help you solve your problems. Technical data sheets available on all coatings. Write Liberty Mirror Division, 6231 Libbey-Owens-Ford Building, Toledo 1, Ohio.

For more information, turn to Reader Service card, circle No. 401

Designed with Wall Colmonoy Stainless Brazing . . . A Case History:

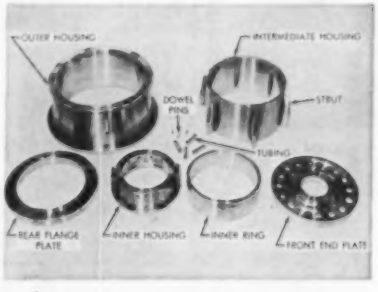
Brazing Speeds Building of Jet Engine Diffuser

The stringent design requirements of this diffuser assembly were met by stainless furnace brazing. The number of manufacturing operations were also reduced, cutting total cost.

The parts shown had to be joined for high performance service conditions. The Nicrobraz® stainless brazing filler metal used produced joints as strong as the parent metal.

Inaccessibility prevented machining after assembly, so allowable tolerance was only (plus or minus) .002". Precision application of brazing filler metal and of furnace temperatures kept distortion within the limits.

Call or write for more information about how our stainless brazing facilities can help you.



Wall Colmonoy Stainless Furnace Brazing Gave These Important Benefits:

- **Brazed joints as strong as parent metal**
- **13 parts joined in one brazing operation**
- **Distortion held to within ±0.002"**
- **No finish machining was needed**
- **Brazed assembly was fully annealed**
- **No clean-up, assembly was bright and clean**

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Stainless Processing Division
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Representatives in all key industrial areas

PROCESSING PLANTS: Detroit, Michigan • Morrisville, Pennsylvania • Dayton, Ohio • Montebello, California

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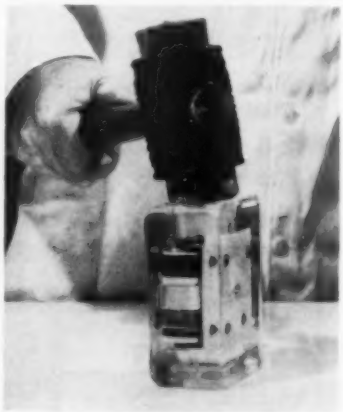
What's new IN MATERIALS

and other contaminating particles from electronic parts. Components embedded in the material can be repaired or replaced by removing a section with a sharp instrument. New material can be poured into the cut-out section and cured without leaving evidence of repair.

The new compound flows freely in and around complicated electronic parts because of its low viscosity in uncured form (800 to 1500 cps).

KEY NO. 623



***Clear silicone** protects electronic parts against shock.*

Columbium Steels Have High Strength

Two new columbium-bearing high strength, low alloy steels have been introduced recently by Armco Steel Corp., Middletown, Ohio.

Called No. 6 and No. 7, the steels have minimum yield strengths of 50,000 and 45,000 psi, respectively. Composition has not been revealed.

Corrosion resistance of the new grades is equivalent to that of mild, non-copper-bearing steels. Formability characteristics permit simple bending across the rolling direction, flanging, and light forming operations of the type regularly performed on standard commercial quality sheet and plate.

Grade No. 6 is similar in welding properties to a 0.20% carbon steel, and No. 7 compares with a 0.10% carbon steel.

The new grades are available as plates, hot rolled sheets and hot rolled

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- Seasoning
- Testing

Seven Revco cabinets, both chest and upright styles, are available. Capacities range from 1.5 to 6 cu. ft. in chests and to 22 cu. ft. in uprights. Units provide temperatures to −140° F. controllable within ±1°. Optional accessories are offered. Immediate delivery on all units.

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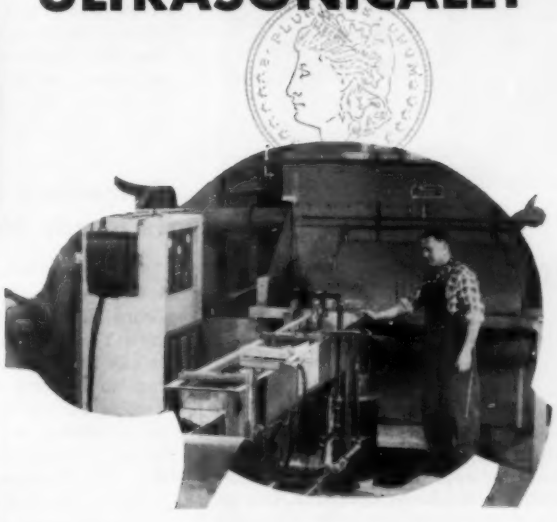

An experimental installation for removal of residual smudge from shot blasted strip by means of ultrasonics. A joint project of Pangborn Corp., Wean Engineering Co., Inc., and Branson Instruments, Inc.

The shotblast method of descaling strip is becoming more and more popular, especially among the lower tonnage producers, converters and fabricators. In this process, hot bands are descaled in a blast cabinet with abrasive shot.–Today ultrasonic cleaning is on the way to replacing flash pickling. This method, which eliminates stream pollution and acid disposal, offers many extras:

• LOW INITIAL INVESTMENT (for tanks due to inexpensive steel construction) • LOW MAINTENANCE COSTS • LOW OPERATING COSTS (in terms of heat and power input) • REDUCED OPERATING TEMPERATURES • LITTLE OR NO CORROSION • NO FUME REMOVAL • NO ACID DISPOSAL • SPACE SAVING • (ultrasonic installations are shorter in length).

Branson's highly experienced, factory trained specialists stand ready to assist you anywhere in the U. S. Tell us about your particular problem and Branson's engineering department shall try to find the best possible solution in the shortest possible time.

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VISCOELASTIC PROPERTIES OF POLYMERS

By JOHN D. FERRY, *University of Wisconsin.* In an exacting and uniform treatment of the viscoelastic properties and behavior of polymers, the author carefully develops a discussion of the phenomenological theory of viscoelasticity, then follows it by presenting a great variety of experimental methods, plus a critical appraisal of their applicability to polymeric materials of differing characteristics. *1961. 482 pages. $15.00*

INTRODUCTION TO CERAMICS

By W. D. KINGERY, *M.I.T.* Embodies a fresh concept in the study of ceramics. Rather than focussing on the various divisions of the industry, it concentrates on phenomena (densification during firing, etc.), properties, and strength. This approach leads to a rational understanding of traditional ceramic compositions and the novel space-age developments. **NOTE:** This book includes an extensive collection of micrographs, showing compositions, processing techniques, and properties. *1960. 781 pages. $15.00*

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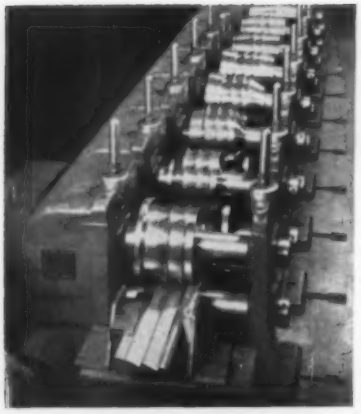

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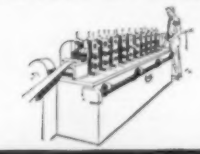

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COLD ROLL FORMING MACHINES

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What's new IN MATERIALS

strip. Hot rolled products of both grades can be supplied in the pickled condition. Maximum length for pickled sheets is 200 in. for sheets up to 60 in. wide, 180 in. for sheets 60 to 72 in. wide. KEY NO. 625

Refractory Cement Is Ready Mixed

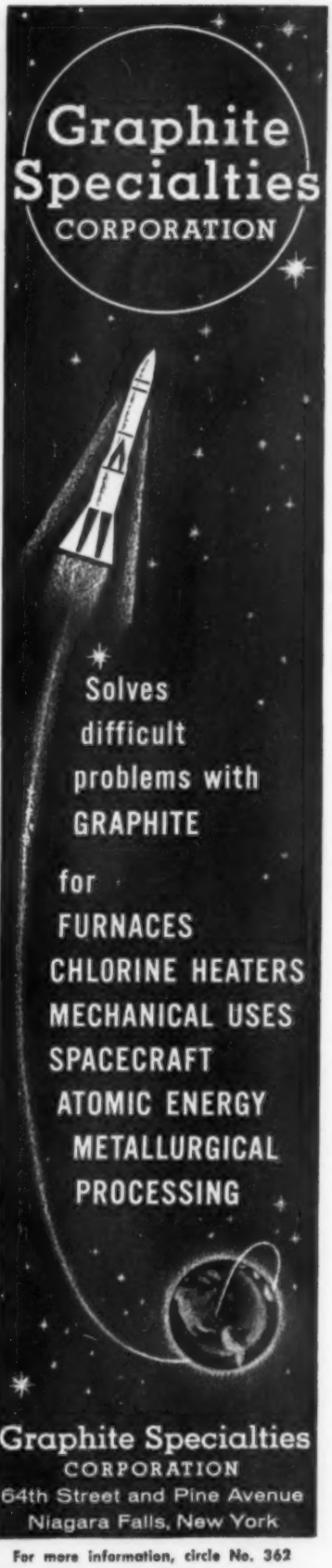
A ready mixed, air setting refractory cement has been introduced by Johns-Manville Corp., 22 E. 40th St., New York 16. Called Super Blakite, it can be used as a refractory coating on vertical boiler tubes, as a cement for refractory masonry, and as a coating on the inside surfaces of duct linings that are subjected to flue dust abrasion.

The refractory cement is furnished in a stiff consistency for use as a trowel coating and is directly applied from the container. It can be applied to smooth metal plates that are directly overhead. The cement will not crack when subjected to heat. KEY NO. 626

Stainless Steel Has Mirror-Like Finish

Three steel producers announced recently that they are producing bright annealed stainless steel strip in tonnage quantities in the types,

***Exit side** of the new continuous bright anneal furnace at West Leechburg Works of Allegheny Ludlum Steel Corp.*



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CERROTECHNICS saves TIME • LABOR • MONEY

in bending thin-walled tubing

CERROTECHNICS is the practice of using low-temperature-melting CERRO* ALLOYS to expedite many industrial operations.

For instance: in bending thin-walled tubing and molding, CERRO-BEND is an ideal filler. It is poured into an inclined tube immersed in hot water. The loaded tube is then removed and quenched in cold water, after which it is bent over a forming block or in a bending machine. The alloy melts out in boiling water.

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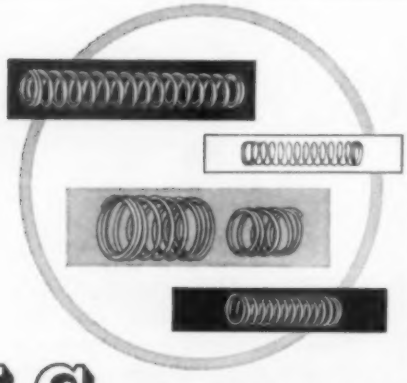

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What's new IN MATERIALS

widths and gages most used by auto and appliance manufacturers.

The three producers are: 1) Sharon Steel Corp., Sharon, Pa.; 2) Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22; and 3) Wallingford Steel Co., Wallingford, Conn. All three companies supply the bright annealed strip at no additional cost over conventional stainless steel strip.

Bright annealing of stainless steel is not new, but previously it was done only on limited quantities of thin gages and narrow widths.

The new steel has a mirror-like finish and improved corrosion resistance. The bright finish eliminates the need for costly buffing and pickling operations. And tests show the bright annealed strip passes the rigors of the Cass and other corrosion tests. Another advantage is improved workability.

Sharon Steel supplies the strip in widths up to 23 15/16 in.; Allegheny Ludlum and Wallingford in widths up to 27 in.

Strip is bright annealed by passing it through an inert atmosphere of hydrogen or disassociated ammonia. **KEY NO. 627**

Optical Materials Used in High Speed Aircraft

New infrared-transmitting optical materials for use under the temperatures and stresses of high speed flight have been announced by Eastman Kodak Co., Apparatus and Optical Div,, Rochester 4, N. Y.

***Molded lens** made of new optical material gives high lens power with relatively shallow curve.*

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uniform accuracy saves costly machining

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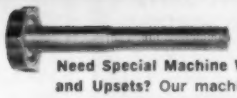

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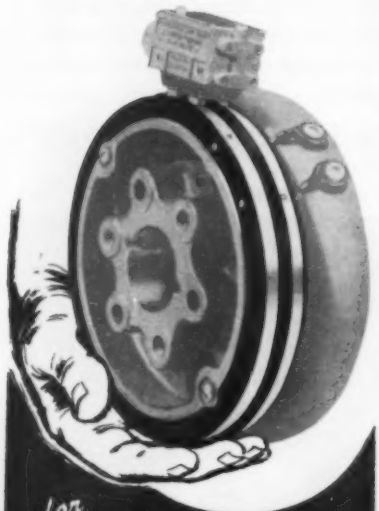
example...

FIBERITE

at work in electric clutches



for Warner Electric Brake and Clutch Co., Beloit, Wis.

Warner Electric needed a plastic molded part to transmit power from brushes to a clutch magnet and turned the job over to Toledo Commutator Co., Owosso, Mich., and Great Lakes Plastics, Inc., Salem, Mich. These were some of the specifications—

- compatibility with bronze inserts from −20 to +200° F
- stability under rotational speeds to 3600 rpm
- dielectric resistance up to 2000 volts
- machinability
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- minimum weight
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FIBERITE No. 4032 olive green (2 stage glass phenolic compound) did the job superlatively. On a production basis!

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They are called Irtran. Composition has not been disclosed.

One of the optical materials has retained infrared transmittance for 1 hr at a temperature of 1800 F. And the infrared transmittance of a number of the other new materials is unaffected after long periods at 1300 F. This is said to be important if the infrared seeing eyes of a speeding missile are to operate at the high temperatures caused by friction in the earth's atmosphere.

The optical materials are made in various shapes ranging from projecting domes to windows or eyes for heat-seeking missiles. The materials can be used for unaffected transmission or for lenses to direct radiation to a certain point.

Kodak says Irtran optical materials are polycrystalline compounds formed by special hot pressing techniques into a variety of shapes and thicknesses. Hot pressing converts powdered crystalline material to a hard, nonporous solid. KEY NO. 628

Polypropylene Tubing Useful up to 300 F

A new stabilized polypropylene tubing called Impolene can be used at temperatures up to 300 F and at working pressures up to 450 psi.

The producer, Imperial-Eastman Corp., 6300 W. Howard St., Chicago 48, says the tubing has 30 to 50 times the life of nylon tubing at elevated temperatures. And the new polypropylene tubing can be used at working pressures three to four times higher than those used with polyethylene tubing.

Impolene tubing is said to have excellent corrosion resistance: e.g., it shows no detrimental effects in boiling sulfuric acid, resists concentrated hydrochloric acid, and withstands saline solutions at temperatures over 212 F.

The tubing shows nearly zero water absorption and extremely low

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A DOUBLE INSERT Part, automatically produced

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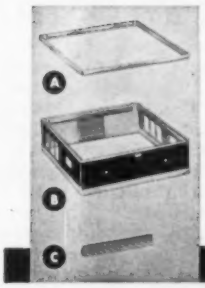

This new Webcor tape recorder weighs 19 lbs., has a case with three vital parts of extruded aluminum by General Extrusions Inc. G.E.I. engineers easily met the manufacturer's design specifications, then the parts were formed, drilled, punched, mitered, anodized and spray painted in G.E.I.'s modern plant in time to meet exacting delivery schedules. Why not let G.E.I. help get your new product off the drawing board and into production?

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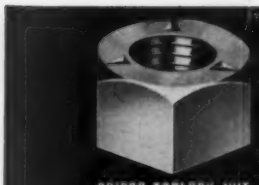

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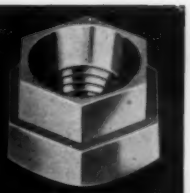
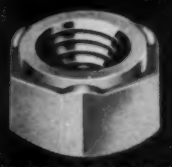
One piece all metal.



GRIPCO CLINCH NUT
With or without self-locking threads. Hex collar prevents turning when torqueing bolt.

You get these "extras" when you specify GRIPCO®



GRIPCO PILOT-PROJECTION WELD NUT
With or without self-locking threads. Centering collar positions nut and protects threads from weld spatter.

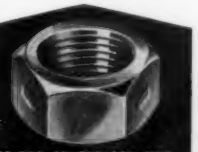
FASTENERS—

Service — 40 sales representatives all over the country for prompt, fast service.

Reliability — Quality controlled by the oldest established lock nut manufacturer in the U.S.

Stock — Large inventories to ensure out of stock delivery on all catalogued items.

Speed production and lower costs on your products with this GRIP NUT family of GRIPCO FASTENERS. Qualified fastener engineers are available for consultation on all your assembly problems. Consult the yellow pages in your phone book under "GRIPCO" for the one nearest you.



GRIPCO CENTERLOCK NUT
Locking feature in the center for fast feeding. Can be applied from either end.

Other Gripco Products:

- Brass Toplock or Centerlock nuts.
- Miniature weld and clinch nuts, with or without lock.
- Toplock and Centerlock Hi Nuts.
- Standard Semi-finish full and jam nuts.
- Stainless Steel lock, weld and semi-finish nuts.
- Cold formed special nuts or parts to print.

Send for samples and NEW CATALOG today

GRIPCO COUNTERSUNK WELD NUT
With or without self-locking threads. Countersink protects threads from weld spatter.

GRIP-NUT COMPANY

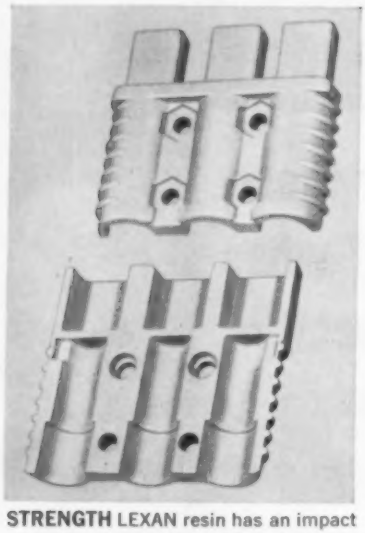
125

101 BROAD ST.
SOUTH WHITLEY, INDIANA
Phone: South Whitley 723-5111

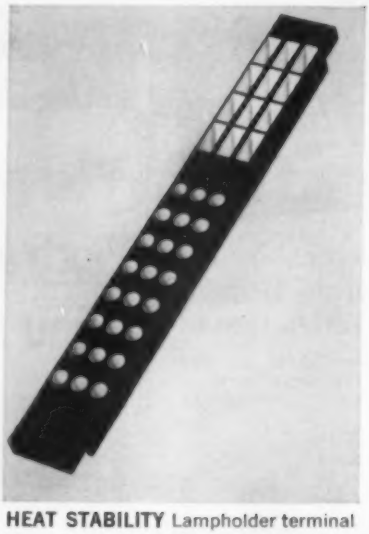
Subsidiary of Heli-Coil Corporation, Danbury, Conn.

For more information, turn to Reader Service card, circle No. 327

G-E LEXAN® POLYCAR



STRENGTH LEXAN resin has an impact strength of more than 12 foot-pounds per inch of notch — higher than any other plastic! This toughness, plus heat resistance and good electrical properties, make LEXAN resin an outstanding choice for 3-pole connectors used in rugged service on electric trucks.



HEAT STABILITY Lampholder terminal block is used inside electronic equipment where heat is difficult to dissipate. LEXAN polycarbonate resin replaced another thermoplastic which melted under severe thermal conditions. LEXAN has a heat distortion point as high as 290°F. Also keeps high strength in sub-zero cold.

ELECTRICAL PROPERTIES A good dielectric, LEXAN resin is non-corrosive even when used with very fine Class F magnet wire. Coil forms must not distort at temperatures above 200°F under stresses caused by tightly wound wire. LEXAN resin provides high heat distortion temperatures under load.

absorption of mineral and vegetable oils. It is odorless and tasteless, and is suitable for food processing applications. **KEY NO. 657**

Protective Tin Coating Is Applied Quickly

A new chemical process for depositing a protective tin coating on metal surfaces has been developed by Shipley Co., Inc., Walnut St., Wellesley 81, Mass. Called Cuposit LT-26, the chemical produces a stable solution, and coating is accomplished instantly by quick dipping.

The process is said to offer three advantages over other tin coating methods: 1) it operates at temperatures much lower than those used in hot dip tin processes, 2) it does not require the use of electricity, and 3) it contains no cyanide.

According to the developer, the new coating can be used to reduce soldering problems on printed circuits, eyelets, connectors, plugs, component leads and other electronic hardware. It can also be used for preventing oxidation on copper, copper-base alloys, lead-tin electroplates and other materials. **KEY NO. 658**

Other News . . .

Metals

▸ Extra large rolled plates made of resistance welding alloys Ampcoloy 95 and 97 are now available from Ampco Metal, Inc., 1745 S. 38th St., Milwaukee 1, Wis. Thicknesses of the plates range from ⅜ to 1⅛ in., widths up to 60 in. and lengths up to 156 in. Potential uses include backup plates and bars, welding dies and die inserts. **KEY NO. 630**

Plastics

▸ Hysol Corp., Olean, N. Y. has introduced a two-part, liquid epoxy insulating system for high performance electrical and electronic equipment. The casting system was developed specifically to meet the requirements of military specification MIL-I-16923C, types B, C and D. **KEY NO. 631**

▸ A rag paper-nylon laminate can be used as an electrical insulation in hermetic applications. The developer, Rogers Corp., Rogers, Conn., says nylon film is extruded directly onto the paper in a molten state, eliminating the need for an adhesive and thereby reducing toluol extractibles. **KEY NO. 632**

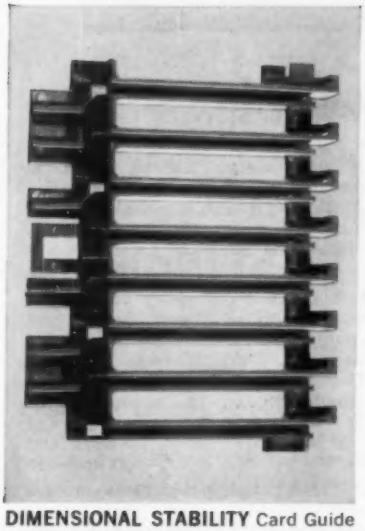
▸ Glass-reinforced plastics pipe made of isophthalic polyester resin is said to perform satisfactorily at temperatures up to 350 F. The pipe is available in outside diameters of 4 to 12 in. It is marketed by Reflin Co., 5730 Kearney Villa, San Diego 11, Calif. **KEY NO. 633**

▸ Formica Corp., 4614 Spring Grove Ave., Cincinnati 32, Ohio has developed a new copper-clad plastics laminate designated XXXP-36RE. The laminate is said to have good impact resistance and high flexural strength. It is supplied in thicknesses from 1/32 to 1/4 in. **KEY NO. 634**

▸ An electrical insulating material that is said to combine the good electrical properties and mechanical strength of vulcanized fibre with the low moisture absorption of phenolic laminates has been announced by National Vulcanized Fibre Co., 1060 Beech St., Wilmington 99, Del. Known as Anilite, the new material is supplied in sheets 0.004 in. to ⅛ in. thick, and 48 in. wide by 72 in. long. **KEY NO. 635**

▸ Two new flame retardant phenolic laminates are now available from St. Regis Paper Co., Panelyte Div., 150 E. 42nd St., New York 17. Designated Grades 833 (unclad) and 8334 (clad), the laminates are particularly suited as insulating bases for many printed circuit applications which previously required more expensive epoxy-paper laminates. **KEY NO. 636**

BONATE RESIN TOUGHEST OF PLASTICS!



DIMENSIONAL STABILITY Card Guide for business machines is molded to close tolerances . . . must undergo minimum change in dimensions during service. Parts show excellent dimensional stability under moist and high temperature conditions. LEXAN resin meets self-extinguishing requirement.

TRANSPARENCY Stock shapes and film of LEXAN polycarbonate resin have excellent transparency. Bar stock is easily machined; film can be thermoformed, heat-sealed and solvent-sealed. Combination of clarity, toughness and malleability gives LEXAN resin the design capabilities of a transparent metal!

LEXAN OPENS UP NEW OPPORTUNITIES... Even before LEXAN entered large-scale production, manufacturers, impressed by its exceptional properties, developed and field tested over 300 applications. G.E. participated in these developments. With the opening of new G-E facilities capable of producing millions of pounds of LEXAN per year, the price of this versatile thermoplastic has dropped dramatically — over 40% in a single year. This fact alone has brought many new products within the range of feasibility. Can you afford to overlook the opportunities presented by LEXAN? Send for details on price, properties, applications and G-E's technical assistance program today! General Electric, Chemical Materials Department, Section M-31, Pittsfield, Mass.

LEXAN®
Polycarbonate Resin

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 394

▸ A new vinyl tank lining material is designed for use in food storage tanks handling both dry and liquid foods. The lining, called Koroseal, is marketed by B. F. Goodrich Industrial Products Co., Akron, Ohio. **KEY NO. 637**

▸ A high density, pressure-molded TFE sheet is said to have better strength and dimensional properties than currently available TFE sheets. The new TFE sheet is sold by Fluorocarbon Co., 1754 S. Clementine St., Anaheim, Calif. **KEY NO. 638**

▸ A new copper-clad laminate is designed primarily for microwave and UHF printed circuitry. The laminate, called Tellon 3A, is available from Tell Mfg. Co., 520 Cary St., Orange, N. J. It is supplied in thicknesses from 0.020 to 0.125 in. **KEY NO. 639**

▸ Rayclad Tubes, Inc., Redwood City, Calif. has introduced a new transparent irradiated insulation sleeving called Thermofit. When heated, the sleeving shrinks to a smaller and predetermined size. The sleeving (composition not disclosed—presumably a polyolefin) can be used over the temperature range –67 to 275 F. **KEY NO. 640**

Other nonmetallics

▸ Porous shapes in alumina or magnesia ceramics for experimental use in fuel cell research are now available from American Lava Corp., Manufacturers Rd., Chattanooga 5, Tenn. **KEY NO. 641**

▸ A perforated vinyl-coated acoustical felt is said to provide from 100 to 300% more sound absorption than currently used sound absorbing materials. Introduced by Western Felt Works, 4021 Ogden Ave., Chicago 23, the flameproof felt is expected to be used as a lining material in business machines, computer equipment and other applications where noise abatement is a requirement. The felt is supplied in rolls and in cut parts. **KEY NO. 642**

▸ Electronic Mechanics, Inc., 101 Clifton Blvd., Clifton, N. J. has announced production of a nonwarping printed circuit board made of glass-bonded mica with deposited copper. The circuit board, called Mykroy, does not outgas, absorb moisture or support combustion. It is supplied in sizes up to 19 by 29 in. **KEY NO. 643**

▸ A nonwoven, cross reinforced fiberglass tape for armature banding has been introduced by Coast Mfg. & Supply Co., P. O. Box 71, Livermore, Calif. under the tradename Vec-O-Tex. The tape has high strength and does not split during installation. **KEY NO. 644**

▸ A heavy-duty, laminated hardwood is recommended as flooring for trucks and trailers. The laminate, called Dura-Wood, is shipped precut to exact specifications. The developer, E. L. Bruce Co., 1648 Thomas St., Memphis 1, Tenn., says the new type of flooring can be installed in a fraction of the time required for ordinary wooden floors. **KEY NO. 645**

Finishes

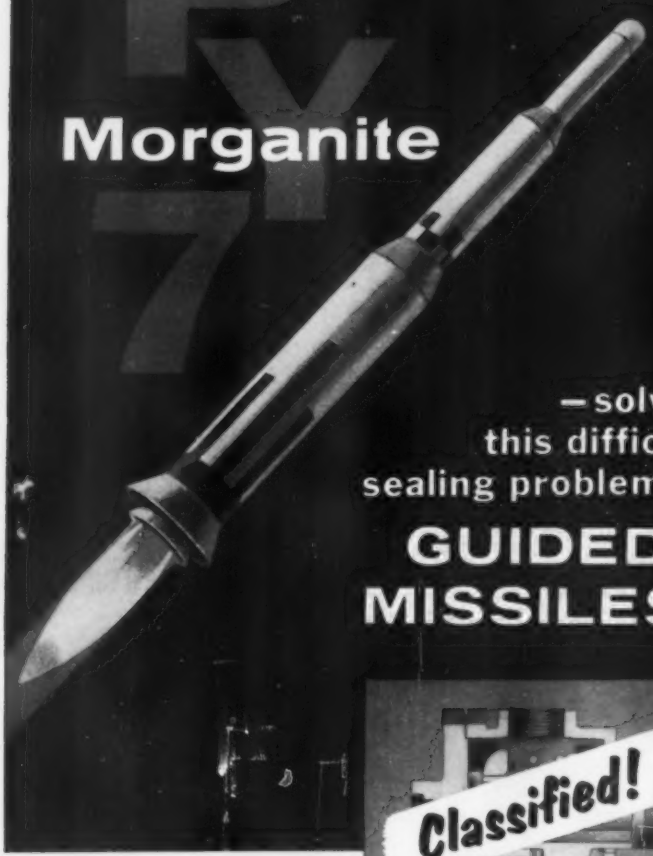
▸ Three new barrel finishing compounds have been introduced recently by Almco, Queen Products Div., King-Seeley Corp., Albert Lea, Minn. No. 101 is a powder specifically formulated for burnishing aluminum, zinc, stainless steel and other metals to a high luster; No. 101A is a cleaning and burnishing liquid for metals; and No. 403 is a neutral abrasive compound that can be used for deburring ferrous and nonferrous metals. **KEY NO. 646**

▸ A line of silicone and silicone-ceramic coatings has been designed to protect metals at temperatures up to 1400 F. The coatings are available in any color from Dampney Co., Hyde Park, Boston 36, Mass. **KEY NO. 647**

▸ A gold polyester coating can be used to produce decorative effects on a variety of consumer goods. The coating, designated IC-2168, is available from Interchemical Corp.,

PY7

Morganite



—solves this difficult sealing problem in

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Morganite PY7 Seals provide high reliability in this missile application where premium performance is essential due to severe environmental conditions. Combustion gases at 900°F are on one side, oil at low temperature on the other. Speed is 3600 R.P.M., face load 20 lbs. and mating surface is stainless steel.

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What's new IN MATERIALS

Finishes Div., 224 McWhorter St., Newark 5, N. J. **KEY NO. 648**

▸ Mitchell-Bradford Chemical Co., Wampus Lane, Milford, Conn. is marketing a new compound called Black Magic that deposits a durable black finish on zinc, zinc electroplates, and zinc-base die castings. **KEY NO. 649**

▸ A ready-mixed epoxy enamel for maintenance coating of surfaces and equipment exposed to alkali and acid fumes is available from E. I. du Pont de Nemours & Co., Inc., Wilmington 98, Del. The material, called Corlar, dries tack-free in 6 hr and can be used on wood, masonry and metals. **KEY NO. 650**

▸ Three phenolic coating resins are now available in a new, free-flowing granulated form from Union Carbide Plastics Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17. The resins are Bakelite brand CKR-2400, CKR-2432 and CKR-5254. They are available at no extra cost. **KEY NO. 651**

▸ A single-immersion chromate conversion coating for zinc electroplates has been introduced recently by MacDermid Inc., Waterbury, Conn. The material, called MaCro Brite 2, produces a clear, bright finish with a chromium-like blue tint. **KEY NO. 652**

Joining, fastening

▸ Development of a new heat-sealable adhesive for aluminum foil has been announced by Rubba, Inc., 1015 E. 173rd St., New York 60. The adhesive, designated Rubba-Foil, dries to a transparent film. **KEY NO. 653**

▸ A heavily coated, low alloy steel electrode has been added to a line of welding electrodes currently available from Metal & Thermit Corp., Rahway, N. J. Deposits from the electrode contain about ½% molybdenum introduced through the coating. The electrode, called Speedex 710 Mo, is recommended for joining high pressure piping, tanks and boilers. **KEY NO. 654**

▸ EZ-4523 is the name of a solvent-type, quick setting adhesive especially designed for bonding expanded polystyrene to wood, metal and other materials. The new adhesive is available from Permacel Inc., New Brunswick, N. J. **KEY NO. 655**

▸ A new heat setting adhesive can be used to bond vinyl plastisols to metals, glass, ceramics and other materials. The adhesive, called Pilogrip 22-4, is marketed by Goodyear Tire & Rubber Co., Chemical Div., Akron, Ohio. **KEY NO. 656**

Materials, forms, finishes and related products

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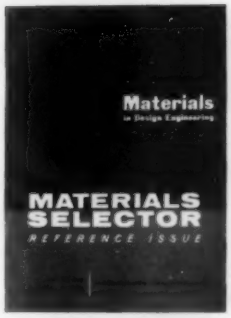
For more complete information, and application data on their lines, refer to the index of Advertisers in the Mid-November MATERIALS SELECTOR ISSUE *of* MATERIALS IN DESIGN ENGINEERING.



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THE LAST WORD

Better Reliability Takes Joint Effort

by ***H. R. Clauser***
Editor

In this modern era of jet flight, electronic brains and atomic energy, freedom from service failure has become an increasingly important engineering consideration.

Of course, reliable performance is and always has been a factor in the design and manufacture of most industrial and consumer products. A breakdown in a piece of industrial equipment often means a costly work stoppage. And a failure in a consumer product, though not catastrophic, can cause the user to switch brands next time he buys.

But it is the current demand for much higher levels of trouble-free service than we are accustomed to that has intensified the concern over reliability. In many of the products of our modern technology 100% reliability of critical parts is demanded. A single failure in a jet airplane, for example, can be (and has been) catastrophic. And in missile electronic systems, one transistor failure can mean the loss of a multimillion dollar missile. That is why part failure rates of as little as 0.01 and 0.001% per 1000 hr are demanded in missile and space vehicle electronic equipment. Reliability of 99.99% may seem an excessive demand, but a system containing 1000 components of such reliability has itself only 91% reliability.

Materials play critical role

In the push to higher reliability levels, materials play the key role. For it is axiomatic that the reliability of a part can be no better than that of the material used.

It is plain that the engineer cannot ignore reliability considerations in applying engineering materials. Thus, when he wants to use a new or different material, it is not enough for him to make his selection on the basis of service and fabricating properties. Important as these considerations are, he must also consider the quality or the reliability of the material in the intended application.

The adoption of new high strength alloys for jet landing gear is a case in point. In a paper presented last fall at the Metal Show, Joan Barriage, Federal Aviation Agency, pointed out that even though the strength properties of the new alloys were adequate, their greater notch sensitivity resulted in lower reliability, which had to be compensated for in design and fabrication of the part.

Design and fabrication important

The case just cited suggests that the reliability of a material's performance is also closely related to design and fabrication. The classic example is the case of the all-welded "victory" ships. When a number of these merchant vessels broke apart in service, many people hastily concluded that welding, per se, was the cause of the failures. However, extensive investigations showed that the fractures usually occurred because design detail or welding techniques did not take into account the notch-sensitivity of the steel.

And finally, materials producers and suppliers share in the responsibility for achieving better reliability. As the allowable failure rates become more stringent, the materials user must depend on his supplier to provide higher quality material to meet the stiffer requirements. This requires the cooperative efforts of supplier and user in developing quality limits on processing and service properties.

It is certain that reliability requirements for many products will continue to grow more stringent. It is evident that to meet those requirements the combined efforts of everyone involved with materials will be needed.

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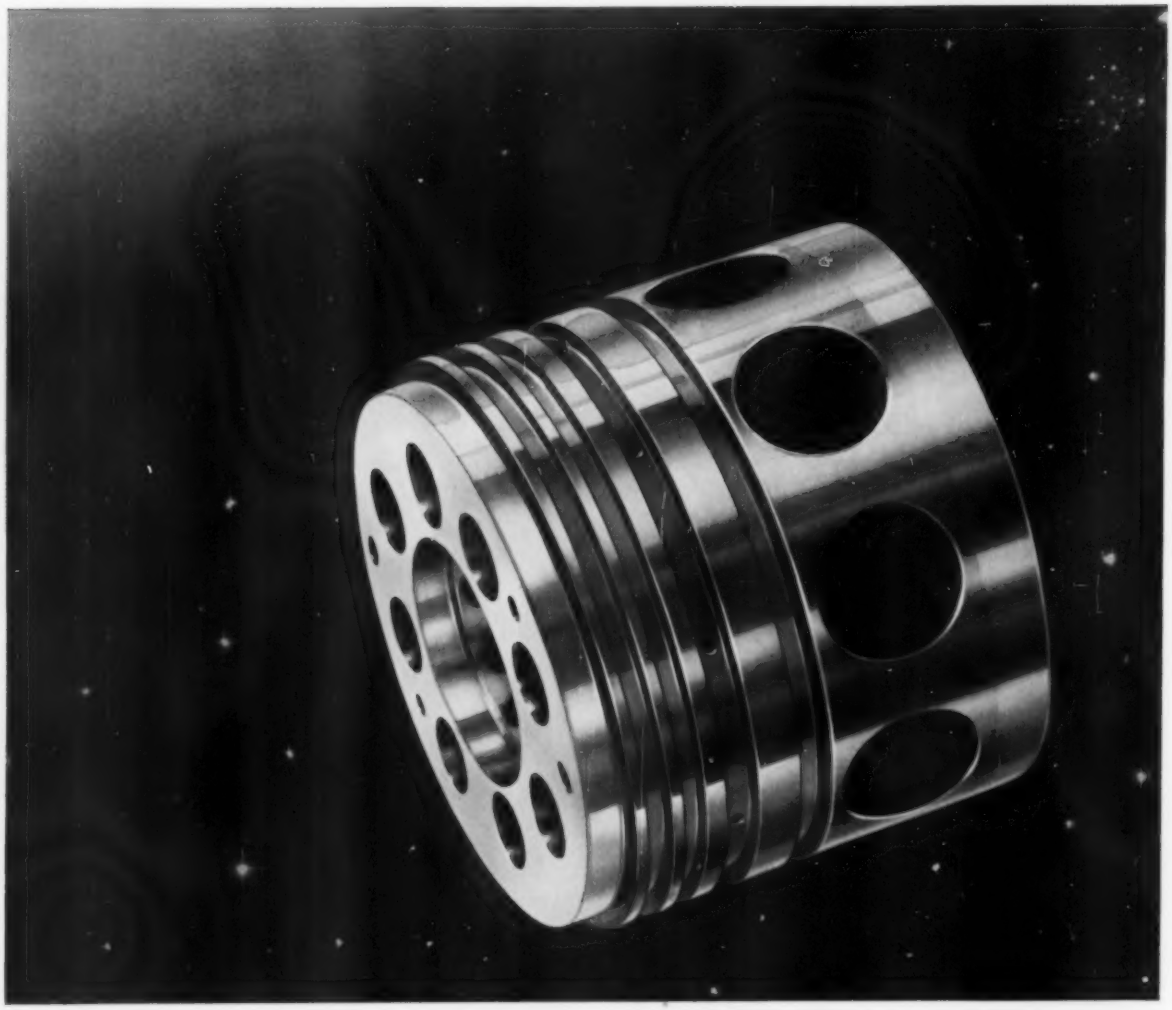

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